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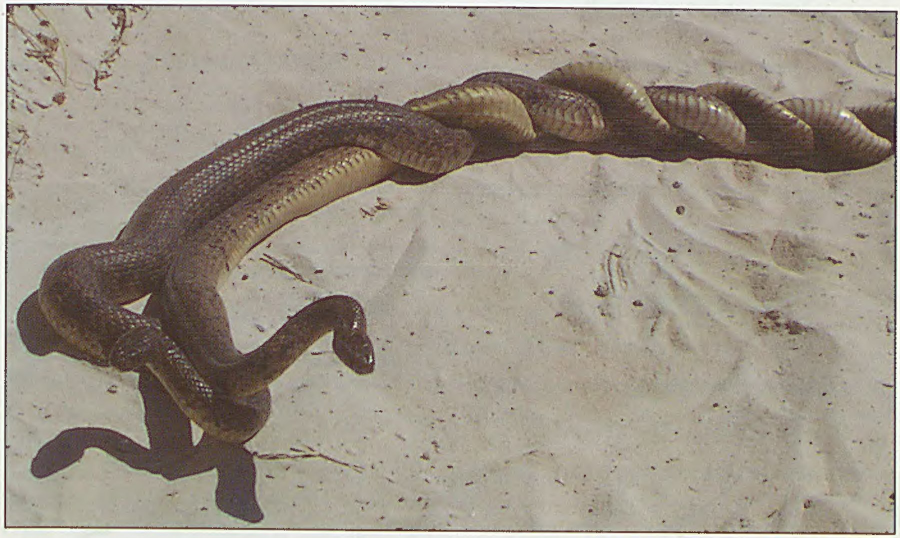

Male combat in dugites, *Pseudonaja affinis*, near Grey, Western Australia. See paper on page 80. (Photo: O. Jenson)

Tapping Green-eyed Frog, *Litoria genimaculata*, from Kirrama State Forest, Queensland, eating a large grasshopper. See paper on page 97. (Photo: J. Rowley)

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TWO NEW RECORDS OF *DELMA MITELLA* SHEA, 1987 FROM THE WET TROPICS

Scott van Barneveld
School of Biological Sciences, Building A08, University of Sydney, NSW 2006.

Delma mitella is one of Australia's least collected pygopods, known only from the Wet Tropics Bioregion of north Queensland. It was described from two poorly localised specimens from the Atherton Tableland (from "Herberton area" and "Koombooloomba rd, nr Ravenshoe"; Shea, 1987), and has since been reported from near Mareeba and the Paluma area (Couper *et al.*, 2000), Kirrama Range and Tolga (P. Couper, pers. comm. 2006). The Tolga specimen (QMJ80864) comes from 'fragmented dry sclerophyll in grazing land' and the Kirrama Range specimen (QMJ82749) from 'disturbed open eucalypt forest' (P. Couper, pers. comm. 2006). There are only two literature records, both from Paluma, for which habitat data are available: one from open forest and one from the ecotone between open and closed forest (Conroy, 1999). In a review of the conservation status of the Australian reptile fauna, this species was categorised as rare or insufficiently known (Cogger *et al.*, 1993) and is listed as Rare under the Queensland Nature Conservation (Wildlife) Regulation 1994. Here I report an additional two records of *D. mitella*.

The first *D. mitella* (1 October 2002) was found near Lumholtz National Park, north Queensland, at approximately 600 m elevation in the Kirrama Uplands biogeographic region (approximately 20 km west of Kennedy, Qld; grid reference: 371716 Map SE 55-10 Edition 1, Series R 502, Ingham). It was found below a piece of timber in an ecotone bordering mesophyll vine forest and wet sclerophyll forest (*Allocasuarina torulosa, Banksia integrifolia* var. *aquilina, Corymbia tessellaris* and *Eucalyptus resinifera* were the dominant tree species, with *Imperata cylindrica* the dominant ground cover - ground cover was approximately 80%). The area had not been burnt for at least 5 years. This *D. mitella* had a snout-vent length (SVL) of 200 mm and a total length of (TL) 858 mm. This size is much larger than that previously recorded for the species (154 mm SVL [Shea, 1987]), and makes *D. mitella* the largest *Delma* species described so far. In coloration, the dorsal surface was coppery-brown, with the lower lateral and ventral surfaces uniform bright fluorescent lime-green. In contrast to previous descriptions, there were no pale cross bands on the head (although the fifth supralabial, immediately behind the eye, was white and this corresponds to the position of the lower lateral end of the pale head bands in the individuals photographed by Wilson, 2005, and pictured in Couper *et al.*, 2000). There was no narrow bluish-grey stripe along the junction between coppery-brown lateral and lime-green ventral surfaces as reported in Wilson and Swan (2003). Scalation was as follows: seven scales between rostral and frontals; rostral scarcely projecting between the supranasals; six supralabials, fourth below eye; ear-opening conspicuous, slightly horizontally elliptic; four supraciliaries; 13 scales along a line across the top of the head joining the angle of the mouth on each side; 16 midbody scale rows; 55 enlarged pairs of ventrals, three preanal scales; five scales along foot flap; single row of 274 enlarged subcaudals from vent to tail-tip.

The second specimen of *D. mitella* was discovered on 25 August 2003 in the vicinity of Mount Baldy State Forest, north Queensland at approximately 800 m elevation. It was found below a piece of corrugated iron in an ecotone bordering mesophyll vine forest and wet sclerophyll forest. Dominant vegetation was structurally and taxonomically very similar to the abovementioned record. This individual had a SVL of 175 mm and a TL of

520 mm. This individual was generally consistent with the specimen previously described in most aspects of colour pattern. The last 50 mm of the original tail had been lost and regrown, and lacked the bright lime green ventral colouring, being a uniform drab brown colour on the dorsal and ventral surfaces. Two faint vertical bands ran from mouth in front of and behind the eye up to the top of the head, but did not join across the head.

Delma mitella appears to be either very rare or very elusive. Although both of these specimens were easily located below ground cover, they were found in areas subject to numerous opportunistic or long-term herpetological surveys, particularly the site adjacent to Lumholtz NP. This area has been surveyed annually by students from James Cook University for over twenty years, however only one *D. mitella* has been recorded there.

ACKNOWLEDGMENTS

Thanks to Leonie Valentine, Ant Backer and Ross Alford (James Cook University) for assistance describing the first specimen in the field, and to Scott Burnett for verifying the identification of the second individual. Thanks to Glenn Shea and two anonymous reviewers for manuscript comments.

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UNIQUE TAIL REGENERATION IN A PYGMY BLUETONGUE LIZARD, *TILIQUA ADELAIDENSIS*

Aaron L. Fenner[1], Mark N. Hutchinson[2] and C. Michael Bull[1]

[1]School of Biological Sciences, Flinders University of South Australia, GPO Box 2100, Adelaide, SA 5001. Email: aaron.fenner@flinders.edu.au.

[2]South Australian Museum, PO Box 234, Adelaide, SA 5001.

The pygmy bluetongue lizard, *Tiliqua adelaidensis*, is an endangered scincid lizard found exclusively in remnant fragments of native grassland habitat in the mid-North of South Australia (Armstrong *et al.*, 1993; Hutchinson *et al.*, 1994). *Tiliqua adelaidensis* is the smallest member of the genus, with an average SVL of approximately 95 mm. Lizards occupy burrows constructed by lycosid and mygalomorph spiders and use these burrows as both shelter and vantage points for ambushing passing prey (Hutchinson *et al.*, 1994; Milne *et al.*, 2003)

At 1500 hr on 20 March 2006, an adult male pygmy bluetongue lizard was captured near Burra in the mid-north of South Australia with a tail that was about half of the normal tail length. At its posterior end the tail was split into two short forks, one above the other (Figure 1). The forks appear to be regenerating tail buds. This individual probably had suffered significant tail damage and subsequently regenerated a new tail from the wound resulting in development of the 'twin tail' (Figure 1). This is the first reported observation of any form of tail regeneration in *T. adelaidensis*. Three other *T. adelaidensis* out of a total of 300 observed individuals in the 2005-06 spring and summer also had missing tails close to the cloaca. However, these lizards did not appear to have any regeneration beyond small 'buds' and stumps, suggesting that tail regeneration is not normal in this species.

In the genus *Tiliqua*, tails of *T. scincoides* and *T. gigas* have transverse fracture planes on all but the 3 or 4 anteriormost postsacral vertebrae. Fracture planes are lacking in the other members of the genus, including *T. adelaidensis* (Shea, 1992). Hence only *T. scincoides* and *T. gigas* are capable of voluntary caudal autotomy (Cann, 1974). Members of *Tiliqua* are generally slow moving and have a tail that is relatively small compared with the body. This, combined with relatively slow movement away from potential predators, suggests that tail autotomy is unlikely to provide adequate distraction to a predator to allow the individual to escape, limiting the potential benefits of autotomizing the tail (Arnold, 1988). The initial loss or damage to the tail reported here to *T. adelaidensis*, probably resulted from a traumatic injury sustained by the lizard during a predator attack. The subsequent regeneration of the 'twin tail' in this particular lizard, although an extreme example, is what might be expected from tail regeneration after non-autotomic tail loss. Injury occurring in other species of *Tiliqua* occasionally results in the slight regeneration of the tail or a conical 'stump' at the point of transection (Frank, 1969). Tail loss and regeneration in the distal parts of the tail has also been reported in other lizards that also lack the fracture planes needed for caudal autotomy, such as the agamid lizards *Physignathus lesueurii, Ctenophorus cristatus* and *C. pictus* (Hardy & Hardy, 1977; Arnold, 1988). Hence, although tail regeneration is uncommon in species lacking fracture planes, it does occur occasionally.

The most interesting part of this observation is that it appears to be the first documentation of tail autotomy and regeneration in *Tiliqua adelaidensis* and one of only a few to report tail loss and regeneration for the genus *Tiliqua*.

ACKNOWLEDGMENTS

We thank the landholders for allowing us access onto their properties, in particular Chris and Maria Reed, and Dr Glenn Shea for helpful comments on tail autotomy in

Tiliqua. The study was conducted according to the guidelines of the Flinders University Animal Welfare Committee in compliance with the Australian Code of Practice for the use of animals for scientific purposes.

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Figure 1. Pygmy bluetongue lizard, *Tiliqua adelaidensis*, showing unusual regeneration following traumatic amputation.

DIET OF THE MOUNTAIN LOG SKINK *PSEUDEMOIA ENTRECASTEAUXII* AT HIGH ELEVATIONS IN THE SNOWY MOUNTAINS

Ken Green[1] and Will Osborne[2]

[1]NPWS, Snowy Mountains Region, PO Box 2228, Jindabyne NSW 2627.

Email: kenneth.green@environment.nsw.gov.au.

[2]Applied Ecology Research Group, University of Canberra, ACT 2601.

INTRODUCTION

The Australian 'high mountain' environment (*sensu* Körner & Spehn, 2002) supports a comparatively rich reptile fauna (Green & Osborne, 1994; Clemann, 2002) with 12 species occurring at subalpine altitudes (above the winter snowline >1500 m) in the Snowy Mountains of NSW, of which nine occur above the treeline (>1850-1900 m) (Green & Osborne, 1994). Considering this richness, there has been little ecological research on the reptiles that occur at high elevations in Australia.

As part of a series of studies of the feeding ecology of skinks in south-eastern Australia, Brown (1986, 1991) obtained samples of *Pseudemoia entrecasteauxii* (a species found throughout the subalpine and alpine zones as well as at lower elevations) and *Pseudemoia spenceri* (a substantially montane species) on Mt Baw Baw (Victoria) in alpine ash *Eucalyptus delegatensis* forest. The sample of *P. entrecasteauxii* collected at this montane location was very small (n = 3) but an additional ten specimens were examined from montane sites in the Strathbogie Ranges, and a much larger lowland sample was obtained from near Colac in Western Victoria (Brown, 1991). The sample of *P. spenceri* collected at Mt Baw Baw was larger (82 specimens), but this species leads a largely arboreal existence, so its diet is unlikely to be indicative of that of the more terrestrial species of skinks found at higher elevations.

It is believed that most Australian lizards are opportunistic feeders on arthropods, although some species have more restricted diets, centering on prey groups such as ants and termites (Heatwole & Pianka, 1993). Studies conducted in woodland and forest in eastern Australia have shown the importance of arthropod groups such as spiders, beetles, termites, bugs and cockroaches in the diet of ground-layer skinks in woodland or forest environments (Crome, 1981; Brown, 1986; Wapstra & Swain, 1996).

Heatwole and Pianka (1993) noted that in harsh environments, where food may be limiting, reptiles are more likely to exhibit a broader diet, and show little if any specialisation. Although small invertebrates are seasonally common in subalpine and alpine areas of the Snowy Mountains (Green, 1997), the combination of relatively harsh seasonal conditions (such as frequent snowfalls, low temperatures and prolonged cloud cover) and short growing season is unlikely to have favoured reptiles with specialised diets. Additionally, there is a complete absence of termites from subalpine and alpine areas (Green & Osborne, 1994), thus further reducing prey choice. In montane areas, Brown (1991) found that both *P. spenceri* and *P. entrecasteauxii* were opportunistic foragers, feeding mainly on spiders, isopods, adult beetles, adult flies, and bugs; *P. entrecasteauxii* also consumed high numbers of ants and lepidopterans.

Pseudemoia entrecasteauxii, the subject of this paper, is found throughout the mountains of south-eastern Australia but only at lower altitudes in Tasmania (Hutchinson & Donnellan, 1988). In the Snowy Mountains it is very common, and occurs above the winter snowline in subalpine woodland, rocky habitats, riparian zones and dry heathlands and above the treeline to the highest altitudes in Australia where it also occurs in tall alpine herbfield

and the margins of glacial lakes (Green & Osborne, 1994). It is a shuttling heliotherm that is active at the ground layer amongst litter and tussocks but is also semi-arboreal , spending considerable periods active or basking on logs and rocks. Densities can be high above the treeline, and among boulders on the edge of Headley Tarn (1850 m), Green and Osborne (1994) recorded densities of up to eight per square metre.

Specimens of *P. entrecasteauxii* from pitfall traps became available from a study of the diet of the marsupial, dusky antechinus *Antechinus swainsonii* (Green, 1989). These specimens provided an opportunity for us to report on the diet of *P. entrecasteauxii* at higher elevations than previously studied, particularly in regard to the availability of surface-active prey as revealed by the pitfall traps.

METHODS

Two long-term sites of 20 pitfall traps were established in boulder heath above the treeline at 1900 m and just below at 1850 m where there was an overstorey of snow gum *Eucalyptus niphophila*; these sites were trapped each month. Pitfall traps were plastic disposable drink cups, 70 mm in diameter, set in permanent receptacles so that they could be exchanged regularly. Polythene pipes were erected over the receptacles to enable winter access to pitfall traps through the snow. In all other sites (ranging between 1700-2000 m and including all terrestrial habitats in the Snowy Mountains) pitfall traps were open to the air and were only trapped in February. All pitfall traps were left open for four weeks between collections. Pitfall traps contained approximately 20 ml of preservative containing water with added formalin (5% by volume), propylene glycol (4.5%) and propylene phenoxytol (0.5%). Invertebrates that were captured were assigned to Order and measured from the tip of the head to the tip of the abdomen (Green, 1989).

A total of 51 skinks was caught inadvertently in pitfall traps; 49 of these were *P. entrecasteauxii*. The sample included no juveniles. The stomach contents of seven skinks had no identifiable remains. Of the remainder, 27 skinks came from a number of sites in the alpine zone (from *Phebalium* alpine heath, alpine boulder heath and tall and short alpine herbfield) and 15 from the subalpine zone from boulder heath with a seral woodland overstorey (see Green and Osborne, 1994, for descriptions of these habitats).

The composition of the stomach contents by number of prey items was expressed as proportion of all items and arcsine transformed for analysis. Alpine and subalpine diets were compared using Student's T-test with no significant difference found, so all data were combined. To give an idea of prey availability, monthly proportional contents of pitfall traps for November to March for two years and for alpine and subalpine permanent pitfall trapping grids were averaged.

RESULTS AND DISCUSSION

All 44 skinks (42 *P. entrecasteauxii*) included in the analysis were adults, or were individuals approaching adult size. Other skinks caught, but not treated further in this discussion, included a single *Pseudemoia rawlinsoni* (35 mm SVL containing a hymenopteran with eggs) and a *Eulamprus kosciuskoi* (spider and beetle). The earliest capture on the monthly-trapped grids was in October and the latest in May (Table 1). October (and sometimes November) was the earliest month in which invertebrate numbers in pitfall traps increased after winter and by May, numbers approached the winter minimum (Green, 1997) so that active food on the ground could only be described as plentiful from November to March. It must be cautioned that although pitfall traps provide some indication of the likely availability of non-aerial prey, as pointed out by Greenslade and Greenslade (1971), some species of ground layer invertebrates including ants are often preferentially trapped and others may avoid traps.

The four main prey groups numerically, making up 53.7% of all prey items were adult

flies, beetles, and bugs and snails (insect larvae and spiders made up another 18%) (Table 2). The first two were also the most important prey volumetrically for *P. spenceri* on Mt. Baw Baw (Brown, 1986). The next most important at Mt. Baw Baw were termites and hymenopterans whereas, in the Snowy Mountains, the next most important were snails and bugs. The latter were mainly leafhoppers.

The diet of *P. entrecasteauxii* recorded by Brown (1988, 1991) at lower elevations was very similar to that recorded in the present study; in both studies spiders, flies, beetles, and bugs were important dietary items. The main differences were the lack of termites and ants in the higher elevation diet. The former is a consequence of their absence at high elevations and the latter most-likely is due to our samples being obtained mainly in shaded shrub habitat, whereas ants at these higher elevations are more commonly found in more open habitat such as alpine herbfield and bogs (Green & Osborne, 1994).

The presence of snails (Gastropoda) in the diet of *P. entrecasteauxii* in the Snowy Mountains is interesting. This group is usually poorly represented in granitic mountain areas (Pearsall, 1950). None was caught in pitfall traps, although two species were identified from litter samples collected in the permanent pitfall trapping sites. There were interannual and interseasonal differences in the composition of the pitfall-trapped invertebrate fauna (Green, 1997) but the impact of this on diet could not be ascertained because of the clumped distribution of captures of skinks, mainly in January and February.

Brown (1986) suggested that species of *Pseudemoia* rely on primary consumers as food and there is only limited exploitation of detritophores for food. A similar situation was found here and the springtails (Collembola) and amphipods, together comprising a third of all individuals in pitfall traps, were not eaten by the skinks. The secondary consumers, however, were better represented and the harvestman and spiders together made up 11% of the prey compared to 7.1% of the contents of pitfalls. By contrast with *P. entrecasteauxii*, in the same area, diet of the dusky antechinus *A. swainsonii* was dominated by beetles, spiders, moths and flies; bugs were more important for the semi-arboreal *A. agilis* and snails were rarely taken by either (Green, 1989).

Nearly 81% of all prey taken by *P. entrecasteauxii* were $\leq$ 5.0 mm, although skinks were able to take prey much larger than this, particularly moths (probably bogong moths *Agrotis infusa*) (Table 3). These data cannot be compared with data for *P. spenceri* (where 65.1% were in the size class $\leq$ 5.0 mm^3) because Brown (1986) used an estimate of volume whereas here we used a measure of length.

CONCLUSION

In much of the subalpine/alpine country of southeastern Australia, the mountain log skink *P. entrecasteauxii* feeds both by 'sit and wait' techniques and by actively searching for prey (Green & Osborne, 1994). The first technique is similar in essence to the action of a pitfall trap which is dependent on the movement of target species, and the proportional representation of the main two prey types (flies and beetles) in the diet reflected well their representation in the pitfalls. However, some active species such as collembolans and amphipods were not eaten, and snails, never caught in pitfalls, were probably sought after. The feeding technique of *P. entrecasteauxii* is therefore likely to be both adventitious and discriminatory, based on avoidance of certain common species and active searching for favoured prey. Comparative studies of other high mountain reptiles are required to examine the influence of this extreme environment on their feeding ecology.

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Table 1. Month of capture of *Pseudemoia entrecasteauxii* from the Snowy Mountains. 40 permanent pitfall traps were used in all months but in February, 9 of the 15 skinks caught came from an extra 60 pitfall traps set for a wider study of habitat.

Month	No.
October	1
November	7
December	2
January	11
February	15
April	1
May	1
Total	38

Table 2. Stomach contents of 42 *Pseudemoia entrecasteauxii* and occurrence of prey in pitfall traps for November to March for two years from the Snowy Mountains by taxon.

Taxon	No. found in stomachs	Percent of total in:		Frequency of Occurrence – stomachs %
		Stomachs	Pitfalls	
Gastropoda	15	11.2	0.0	23.8
Amphipoda	0	0.0	6.9	0.0
Diplopoda	2	1.5	0.6	4.8
Acarina	7	5.2	8.0	7.1
Harvestman	3	2.2	1.0	7.1
Spider	12	9.0	6.2	26.2
Collembola	0	0.0	20.2	0.0
Siphonaptera	3	2.2	0.0	7.1
Orthoptera	7	5.2	0.1	14.3
Blattodea	1	0.7	0.2	2.4
Hemiptera	14	10.4	1.7	16.7
Coleoptera	16	11.9	12.5	28.6
Diptera	27	20.1	27.0	38.1
Lepidoptera	9	6.7	2.0	21.4
Hymenoptera	5	3.7	7.7	9.5
Larvae	12	9.0	4.9	26.2
Seeds	1	0.7		2.4
n	134			

Table 3. Stomach contents of 42 *Pseudemoia entrecasteauxii* from the Snowy Mountains by size.

Size range (mm)	Number found	Percent representation numerically
0-2.5	60	46.5
2.6-5.0	44	34.1
5.1-7.5	9	7.0
7.6-10.0	8	6.2
10.1-12.5	3	2.3
12.6-15.0	1	0.8
15.1-17.5	0	0.0
17.6-20.0	1	0.8
>20.0	3	2.3

A HERPETOFAUNA SURVEY OF THE CANDOWIE RESERVOIR SECTION OF THE TENNENT CREEK CATCHMENT, ALMURTA, VICTORIA.

Ray Lloyd
School of Tropical Biology, James Cook University, Townsville, Queensland 4814.
Email: Ray.Lloyd@jcu.edu.au.

INTRODUCTION

The Tennent Creek catchment is situated in Victoria approximately 90 km south east of Melbourne (38°27'S 145°34'E) and covers an area of 19.3 km² with elevations ranging from 60 m (at the reservoir) to 255 m above sea level (Master, 1978). The catchment contains a small water storage reservoir (2,270 ML) known as Candowie Reservoir, which is managed by the Westernport Water Authority and supplies water to residents on Phillip Island and the adjacent mainland (Master, 1978). The survey was conducted over a three-week period in December 2003 for the Phillip Island Landcare Group as part of the Westernport Water Biodiversity Asset Register. The survey was restricted to the north-western section of the Tennent Creek catchment, in close proximity to Candowie Reservoir. The reservoir is situated within extensive areas of farmland and contains a large vegetation buffer zone along its boundaries. Apart from roadside vegetation corridors, this site is one of few within the catchment that retains remnant vegetation, providing an important sanctuary for many species of fauna.

VEGETATION

Within the site two distinct vegetation communities exist that are divided by a small outlet creek known as Tennent Creek. The creek is mainly exposed with large sections of rock and bare soil. However, portions of the creek have dense clumps of bulrush *Typha domingensis* and common reed *Phragmites australis*.

Eucalypt woodland

Dominated by southern blue-gums *Eucalyptus globulus* and silver wattles *Acacia dealbata* with a sparse understorey of bracken fern *Pteridium esculentum* and thick leaf litter. This community is patchy and scarce, only occurring along the riparian strips on the south-western boundary of Tennent Creek.

Poa/Gahnia Sedgeland

Largely dominated by tussock grass *Poa* sp. and saw sedge *Gahnia* sp., the site also consists of blackwood *Acacia melanoxylon*, dogwood *Cassinia aculeata*, kangaroo apple *Solanum aviculare* and dense clumps of austral clematis *Clematis aristata*. This vegetation community constitutes a much larger percentage of the study site.

METHODS

The main survey method used in the detection of reptiles and amphibians was pit traps and drift fences. Two 20 m long x 40 cm high drift fences were installed, each containing 5 x 20 litre plastic buckets spaced at approximately 3 m apart. One line was installed in each of the two vegetation communities, eucalypt woodland and *Poa/Gahnia* sedgeland. Pit traps were checked three times daily during the three-week period, once before 0900 hrs, at noon and at 1900 hrs (daylight savings time). Other survey methods employed included non-systematic active searches and driving a 2 km long sealed road, which runs through habitat within the site. All herpetofauna observed during these times were captured, identified and released. Spotlight searches were also undertaken along the creek at night in search of frogs. Species detected at all sites were identified using Wilson and Swan (2003), Cogger (2000) and Ehmann (1992). Frog calls were identified using Littlejohn (1987). The conservation

status of species recorded in the survey are listed as per Greer (2003) and Cogger *et al.* (1993).

RESULTS

A total of 10 species of herpetofauna were identified during the survey period: two species of elapid snake, five species of scincid lizard and three species of amphibian (Table 1).

Higher species diversity was recorded within the sedgeland community, with a total of five skink, one elapid snake and one frog species being recorded. A much lower species diversity was found within the eucalypt community with only three skink species being recorded. All *Crinia signifera, Limnodynastes peronii* and one *Notechis scutatus* were recorded along Tennant Creek, while one *Tiliqua nigrolutea* and one *N. scutatus* were recorded on the road. The sedgeland community was most diverse; it contained most of the species recorded during the survey and several species that were not recorded in the *Eucalyptus* community (*Nannoscincus maccoyi* [McCoy's Skink], *Pseudemoia rawlinsoni* [Glossy Grass Skink], *Austrelaps superbus* [Lowlands Copperhead] and *Litoria ewingii* [Southern Brown Tree Frog]) (Table 1).

Table 1. Species recorded at Candowie Reservoir.

Scientific Name	Common Name	Status	Methods	Habitat	Abundance
Scincidae					
Lampropholis guichenoti	Common Garden Skink	C	T, O	E, G	9
Nannoscincus maccoyi	McCoy's Skink	R	T, O	G	7
Pseudemoia rawlinsoni	Glossy Grass Skink	R	T	G	1
Saproscincus mustelinus	Weasel Skink	C	T, O	E, G	23
Tiliqua nigrolutea	Blotched Blue-tongued Lizard	C	T, O	E, G, Rd	7
Elapidae					
Austrelaps superbus	Lowland Copperhead	C	O	G	1
Notechis scutatus	Mainland Tiger snake	C	O	Cr, Rd	2
Hylidae					
Litoria ewingii	Southern Brown Tree Frog	C	O	G	1
Myobatrachidae					
Crinia signifera	Common Froglet	C	H	Cr	7
Limnodynastes peronii	Striped Marsh Frog	C	H	Cr	3

Codes Used:
Conservation Status: C = Common and Widespread, R = Rare or Insufficiently known
Methods: T = Pit Trap, O = Observed, H = Heard
Habitat: E = Eucalypt Woodland, G = Grass/Sedgeland, Cr = Creek, Rd = Road
Abundance: Refers to number of individuals detected during survey

DISCUSSION

The greatest diversity of reptile and amphibian species was recorded in the sedgeland community. As well as dominating the vegetation of the entire site, the overall structure of these sedgelands tended to create a more diverse array of microhabitats, as each sedge and tussock forms a thick mass of dense habitat. *Pseudemoia rawlinsoni* is thought to be associated with specialized microhabitats and dense vegetation (Wilson & Swan, 2003; Cogger, 2000), and may reflect why this species was only recorded within the sedgeland community. Homan (2003) recorded seven individual *P. rawlinsoni* 25 km south of the study site, six of these were also recorded in a *Poa/Gahnia* sedgeland community. It is not known why *N. maccoyi, A. superbus* and *L. ewingii* were only recorded within this vegetation community. A possible reason could be the slightly lower elevation (1 – 2 m) at the site where the pit traps were installed. This region remained slightly wetter over the summer months (pers. obs.), which could possibly affect the distribution of some species, though it is highly unlikely. *Nannoscincus maccoyi* is generally associated with moist areas, particularly wet soil (Cogger, 2000). *Austrelaps superbus* is generally associated with water, where they primarily feed on frogs, while *L. ewingii* are associated with low ground vegetation (Cogger, 2000).

During the survey, two species of reptile were detected which have been infrequently recorded in this region: *Nannoscincus maccoyi*, previously recorded further north of the study site (Lloyd, unpublished data; Kutt & Yugovic, 1996) and *Pseudemoia rawlinsoni*, only recorded from the Wonthaggi Heathland & Coastal Reserve (Homan, 2003). *Pseudemoia rawlinsoni* is currently listed as rare or insufficiently known (Cogger *et al.*, 1993), though Wilson and Swan (2003) recognize *P. rawlinsoni* as near threatened in Victoria. Only one individual of *P. rawlinsoni* was recorded throughout the survey. This may be due to the short length of the survey; they may also be uncommon within the site. *Nannoscincus maccoyi*, a thigmothermic (non-basking) skink (Greer, 1989), was quite common within the study site. This species may seldom be encountered throughout this region simply due to its part nocturnal/cryptozoic and semi-fossorial lifestyle (Greer, 1989). The first individual *N. maccoyi* recorded during the survey was uncovered while digging pitfall holes. A lack of systematic surveys in this region may also be a possible reason for lack of records.

The survey was conducted at a time of year when the herpetofauna is active and commonly encountered (pers. obs.). The short duration of the survey period may have limited the number of species and individuals recorded in the survey, and several other species have been recorded in close proximity to the site (Appendix 1). Surveys of longer duration may record additional species. No surveys for Freshwater Turtles were conducted within the survey period. *Chelodina longicollis* may occur within the site, as the species has been recorded within 5 km of the site (Appendix 1). Rawlinson (1971) state the species does not naturally occur in the coastal regions west of Sale, Victoria, and it is possible those individuals recorded near the study site may be introduced.

A wider variety of survey methods could have been employed during the survey. Homan (2003) also utilized the pitfall methods; in addition tin survey methods were also used, whereby several lengths of tin were spread out creating refuge for reptiles and frogs. These methods proved to be very efficient in locating many species (Homan, 2003). However, given the short duration of the current survey, this technique may not have been as effective due to time taken for species to colonise these artificial habitats. A longer survey period may thus prove to be an extremely reliable method and should be employed in possible future surveys of this site. The use of reptile funnel traps may also have assisted in capturing more species. This trapping method has worked very well in her-

petofauna surveys in north Queensland, being extremely efficient in the capture of lizards, elapid snakes and myobatrachid frogs (pers. obs.). These traps may also prove to be effective in capturing lizards, snakes and frogs in Victoria and the use of these traps in subsequent surveys should not be overlooked.

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Appendix 1. Species recorded within 5 km of Candowie Reservoir

Scientific Name	Common Name	Source
Scincidae		
Bassiana duperreyi	Three-lined Skink	Atlas of Victorian Wildlife
Egernia coventryi	Swamp Skink	Atlas of Victorian Wildlife
Lampropholis guichenoti	Garden Skink	Lloyd (unpublished data)
Nannoscincus maccoyi	McCoy's Skink	Lloyd (unpublished data)
Pseudemoia entrecasteauxii	Southern Grass Skink	Lloyd (unpublished data)
Pseudemoia rawlinsoni	Glossy Grass Skink	This survey
Saproscincus mustelinus	Weasel Skink	Lloyd (unpublished data)
Tiliqua nigrolutea	Blotched Blue-tongued Lizard	Lloyd (unpublished data)

Varanidae		
Varanus varius	Lace Monitor	Atlas of Victorian Wildlife
Elapidae		
Austrelaps superbus	Lowland Copperhead	Lloyd (unpublished data)
Drysdalia coronoides	White-lipped Snake	Lloyd (unpublished data)
Notechis scutatus	Tiger Snake	Lloyd (unpublished data)
Chelidae		
Chelodina longicollis	Common Long-necked Turtle	Lloyd (unpublished data)
Hylidae		
Litoria ewingii	Southern Brown Tree Frog	Lloyd (unpublished data)
Litoria verreauxii	Whistling Tree Frog	Lloyd (unpublished data)
Myobatrachidae		
Crinia signifera	Common Froglet	Lloyd (unpublished data)
Limnodynastes dumerilii	Pobblebonk Frog	Lloyd (unpublished data)
Limnodynastes peronii	Striped Marsh Frog	Lloyd (unpublished data)
Limnodynastes tasmaniensis	Spotted Marsh Frog	Lloyd (unpublished data)

AN OBSERVATION OF MALE COMBAT IN THE DUGITE *PSEUDONAJA AFFINIS* (SERPENTES: ELAPIDAE) FROM GREY, NAMBUNG NATIONAL PARK, WESTERN AUSTRALIA

Dane F. Trembath[1], Jodi L. Rowley[2] and Oystan Jensen[3]
[1]Applied Ecology Institute, University of Canberra, ACT 2601.
Email: Trembath@aerg.canberra.edu.au.
[2]School of Tropical Biology, James Cook University, Townsville, Qld 4811.
Email: Jodi.Rowley@jcu.edu.au.
[3]Oystan Jensen, ì Gerdinum 20, 380 Sørvagur, Faroe Island (via Denmark).

INTRODUCTION

Male combat between snakes is widespread amongst Australian elapids (Greer, 1997; Shine, 1994). However, published detailed observations of male combat are limited to *Austrelaps* (Shine & Allen, 1980; Lintermans, 1993), *Cryptophis* (Shine, 1984), *Demansia* (Shine, 1980; Covacevich, 1994), *Hemiaspis* (Shine, 1987), *Notechis* (Firmage & Shine, 1996; Fearn & Staubmann, 2001), *Oxyuranus* (Hosmer, 1953; Worrell, 1964; McRae & Covacevich, 1997), *Parasuta* (Turner, 1992), and *Pseudechis* (Shine *et al.*, 1981; Williams, 1992). Additionally, within the genus *Pseudonaja*, male combat has only been observed in *P. textilis* (Fleay, 1943; Shine, 1989; Fyfe, 1993), *P. nuchalis* (Shine, 1989; Fyfe, 1993) and *P. affinis* (Shine, 1991; Maryan, 2004). Despite the widespread occurrence of male-combat, its function remains largely unknown. Observations of male-combat from the field may aid in the understanding of male-combat in snakes, but is lacking for the majority of species.

Pseudonaja affinis occurs in southwest Western Australia and also coastal parts of South Australia (Maryan, 1996). Although a single photograph of combating *P. affinis* has been published previously (Shine, 1991), descriptions of male combat in *P. affinis* only exist for captive snakes (Maryan, 2004). Here we present field observations of male-male combat in wild *P. affinis*.

OBSERVATION

The following observations occurred north of the town of Grey, Western Australia (30°39'S 115°08'E) on 31 October, 2005. At 1200 hrs, two adult *P. affinis* of approximately the same size were observed at the base of a sand dune (Figure 1). The snakes were coiled around each other with the lower two-thirds of their body, while their heads were apart and elevated, moving up and down repeatedly. It appeared that they were attempting to push each others' head to the ground. This behaviour continued for approximately ten minutes, during which time the snakes did not react to the presence of the observer. Unfortunately, the duration and outcome of the interaction is unknown as the observer did not want to disturb the snakes, and moved on after 10 minutes.

The temperature at time of observation was approximately 20°C, and there was approximately 50% cloud cover (Australia Bureau of Meteorology).

DISCUSSION

Combat behaviour is strikingly similar in elapids, colubrids, pythons and vipers (Grant, 1956; Bogert & Roth, 1966; Shaw, 1951). The behaviour observed between combating *P. affinis* in this observation appears typical of most combating snakes (Akester, 1979; Bogert & Roth, 1966). However, despite overall similarities, some variation does exist with respect to bout duration, degree of head elevation, and whether or not biting, snapping and/or hissing occurs (Bogert & Roth, 1966; Shine & Allen, 1980; Shine *et al.*, 1981).

Male combat in snakes is thought to occur primarily in species with a high degree of

sexual dimorphism, with males growing relatively larger than females in species with male combat (Shine, 1978). Though there is little significant sexual dimorphism in snout vent length in the genus *Pseudonaja* (Shine, 1989; Maryan, 1996) males are always relatively larger than females in museum collections (Shine, 1989) and appear to be more robustly built than females which helps to facilitate mate searching and combat (Bonnet *et al.*, 1998).

Male combat in snakes has been most often reported in the mating season (Bogert & Roth, 1966), and male combat between *P. affinis* is no exception. Male combat has been reported to occur in August (this study) and October (Maryan, 1996) in the field and between August and December in captivity (Maryan, 1996) which is within the mating season recorded for captive *P. affinis* (Maryan, 2004).

Although male combat in snakes has been interpreted as a strategy for forcing rival males away from a females (Shine, 1981), no female was observed in the vicinity during this observation, or in other a number of other observations of male combat in snakes (Akester, 1971; Lloyd, 2005). Other suggestions with regard to the reasons for male combat in snakes include defending against homosexual courtship (Shaw, 1951) and gaining access to food items (Shaw, 1951). However, combat may simply occur when two mature males come into contact with each other during the breeding season (Shaw, 1951; Akester, 1971).

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Figure 1. ***Pseudonaja affinis* engaged in male combat near Grey, Western Australia.**

AN INCIDENCE OF CANNIBALISM IN THE ASIAN HOUSE GECKO (*HEMIDACTYLUS FRENATUS*)

J. Lindley McKay[1] and Julia Schult[2]
[1]School for Environmental Research, Charles Darwin University, Darwin, NT 0909. Email: valvolandia@yahoo.co.uk.
Present address: Biodiversity Conservation Unit, Department of Natural Resources, Environment and the Arts, PO Box 496, Palmerston, NT 0831.
[2]School of Science and Primary Industries, Charles Darwin University, Darwin, NT 0909. Email: Julia.schult@cdu.edu.au.

The Asian House Gecko, *Hemidactylus frenatus*, is a familiar inhabitant of homes and buildings in many parts of the tropical and subtropical world, including Australia (Savage, 2002). It is typically regarded to be a generalist insectivore (Wilson & Swan, 2003). In a more detailed dietary study, Ota (1994) reported that in the Ryukus of Japan *H. frenatus* consumes primarily moths (Lepidoptera) and flies (Diptera) in the warmer months, and lice (Isopoda) and cockroaches (Blattaria) in cooler months. Petren and Case (1996) found that the diet of the species on Hawaii consisted of 63% winged termites (Isoptera) and 17% moths, and a study on Socorro Island, Mexico, found that the diet consisted mainly of moths, and also crickets (Orthoptera) and spiders (Aranea) (Galina-Tessaro *et al.*, 1999). However, invertebrates are not the sole food source for the species. Cannibalism has been reported from Socorro Island, Mexico, where individuals of the same species represented 21% of the total volume of prey material (Galina-Tessaro *et al.*, 1999).

The occurrence of cannibalism suggests that *Hemidactylus frenatus* might also be capable of preying on smaller individuals of other species. Bolger and Case (1992) found that in laboratory experiments *H. frenatus* would predate upon smaller individuals of its own and other species. Such behaviour may contribute to its capacity to successfully outcompete other geckos. A recent study on the Mascarene islands found *H. frenatus* preys upon native species of *Nactus* and causes tail and digit loss, as well as outcompeting the smaller geckos for use of refugia. The combination of these factors has probably caused the extinction of *Nactus* on some islands (Cole *et al.*, 2005).

Here we detail an observation which supports the occurrence of cannibalism elsewhere in the species' range, and to our knowledge is the first report of cannibalism in *H. frenatus* in Australasia.

The incident took place on 17 October 2004 at around 8.30pm at 20 Ludmilla Terrace, Ludmilla, Darwin, Australia (WGS 84, 12°25'30.17"S 130°51'01.49"E). *Hemidactylus frenatus* is abundant at this residence and can be seen on any given night on lit internal and external walls. At approximately one hour after dark, one of us (JS) observed two *H. frenatus* in close proximity on a lit internal wall around two metres above the floor. One was an adult, estimated snout-vent length (SVL) 45 mm and the other was a juvenile, estimated SVL approximately 20 mm. The adult lunged at the juvenile, grasped the smaller gecko in its mouth and within a few seconds had swallowed it entirely.

This observation highlights that *Hemidactylus frenatus* has the capacity to consume vertebrates, and depredation could play an important role in the displacement of native geckos by *H. frenatus* in Australia.

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SOUTHERN DISTRIBUTION LIMITS AND A TRANSLOCATED POPULATION OF THE SCRUB PYTHON *MORELIA KINGHORNI* (SERPENTES: PYTHONIDAE) IN TROPICAL QUEENSLAND

Simon Fearn[1] and Dane Trembath[2]
[1]8 Diana Court, Riverside, Launceston, Tasmania 7250.
Email: simonfearn@iprimus.net.au.
[2]Applied Ecology Research Group, University of Canberra, ACT, 2601.
Email: Trembath@aerg.canberra.edu.au.

The Australian distribution of *Morelia kinghorni* (= *M. amethistina* in earlier literature) comprises tropical north-coastal Queensland as well as some Torres Strait islands (Covacevich & Couper, 1991). Throughout this range, *M. kinghorni* has been recorded from a variety of habitat types with closed rainforests and adjoining areas of anthropogenic disturbance appearing to constitute core habitat (Barker & Barker, 1994). While *M. kinghorni* can be locally abundant in areas of core habitat (Fearn et al., 2005), its presence in marginal habitats on the fringes of its preferred range can be difficult to detect. This may account for the uncertainty in the literature as to the southern and western limits of its distribution in northern Queensland. Early authors (Kinghorn, 1929) considered *M. kinghorni* to be localised to the Atherton Tablelands or that the Tablelands represented the southern boundary of the taxon's distribution (McPhee, 1959). This situation undoubtedly reflected the geographical and scientific institutional isolation of north Queensland until well into the 20th century. Worrell (1963), having collected extensively in northern Queensland, extended the known southern range to the Herbert River. Hoser (1989) and Lloyd and Fearn (2005) reported *M. kinghorni* from Mt. Spec, 80 km north west of Townsville, Covacevich and Couper (1991) a single specimen from Townsville, Calvert (1996) from Townsville and from Hervey's Range to the west of that city, and Fearn (1998) from Townsville, Magnetic Island and Alligator Creek, 20 km south of Townsville. More recently, Augusteyn (2004) cited the same Alligator Creek record as Fearn (1998) and erroneously recorded a specimen occurring farther south of Alligator Creek in the Clement State Forest. The Clemant State Forest is in fact to the north of Townsville.

Since 1998, the senior author has collected a further three records from metropolitan Townsville: Belgian Gardens (L. Schwarzkopf, pers. comm.), Riverside Gardens (portion of slough), and the lower southern slope of Castle Hill (M. Pople, pers. comm.). In addition, the authors examined an adult female collected crossing Country Road, Serene Valley (19°22'S 146°53'E), 17 km south of Townsville. R. and A. Field of Townsville have a long family history of herpetology in the Townsville district and they kindly provided the authors with *M. kinghorni* records south of Townsville. Road-killed and live specimens were examined on the Bruce Highway at several locations between Palm Creek (19°30'S 147°02'E) and MacKenzie Creek (19°25'S 147°02'E) and a specimen was examined at Killimoon Creek (19°23'S 146°59'E). All three creeks flow from Mt. Elliot, which has extensive habitat suitable for *M. kinghorni*. Additionally, specimens were recorded at Woodstock (19°35'S 146°50'E) and 200 m north of the Giru turnoff on the Bruce Highway.

In response to this information, the print media was enlisted in April 2001 to encourage the public to report *M. kinghorni* from south of Townsville to the senior author. This approach yielded a number of interesting responses but highlighted the easy confusion of *M. kinghorni* with the more common and widespread carpet python *Morelia spilota*. Many northern Queenslanders do not distin-

guish between the two species and commonly refer to both as 'carpet snakes'. Only responses that included photographs or sloughed skins are presented here. Sloughs were received from Giru (19°30'S 147°06'E). Photographs were sent from Ravenswood (20°05'S 146°53'E), 100 km south west of Townsville, depicting one of several *M. kinghorni* utilising an urban shade house, and from Brandon (19°36'S 147°19'E), 70 km south of Townsville, of a large adult basking on the limb of a fig tree (Fig. 1). It would appear that the natural southern range of *M. kinghorni* in tropical Queensland terminates in the vicinity of the Burdekin River and its northern tributaries. No records of *M. kinghorni* are known from Ayr (8 km south of Brandon); however, anthropogenic destruction of lowland rainforest in this area is nearly total, so it cannot be ruled out that *M. kinghorni* was not present in the area prior to European settlement. From our extensive field work, we suggest that *M. kinghorni* becomes increasingly rare and reliant on humid riparian habitats and vine thickets in sheltered slopes and gullies south of the Rollingstone district (50 km north of Townsville).

In a remarkable range extension, Augusteyn (2004) and Crossman (2004) suggest that a naturally occurring population of *M. kinghorni* occurs in the Conway Ranges in the vicinity of Airlie Beach, 300 km south of Townsville. We suggest that this population represents an accidental introduction involving specimens from the Wet Tropics. The aforementioned media request for *M. kinghorni* records south of Townsville elicited a response from M. Glossat at Cannonvale, 6 km from Airlie Beach, who reported a large scrub python was removed (at her request) from a subdivision in Cannonvale by staff of the Whitsunday Wildlife Park. On 22 April 2001, the senior author visited the site (20°17'S 148°41'E) and inspected the snake in its public enclosure in the Park. The snake was a maximal sized male *M. kinghorni*, 5 m in length and had regurgitated an adult wallaby shortly after capture. The Park's owner, R. Bredl, was interviewed about the presence of *M. kinghorni* in the Airlie Beach area. He unequivocally stated that *M. kinghorni* does not naturally occur in the area and that any specimens present were the result of the escape of a collection of adults from their enclosure at the Park in 1990. We suggest that the fact that one of the largest snakes in the world could remain entirely unknown in the Airlie Beach area for some 200 years of European settlement supports Mr. Bredl's assertion.

If this population does represent a recent introduction, we predict a phase of rapid population growth with *M. kinghorni* becoming increasingly common as well as colonising all suitable, interconnected habitat north and south of the Airlie Beach area. We base this prediction on the apparent suitability of the climate and vegetation of the Airlie Beach area, high species diversity and abundance of potential vertebrate prey for all *M. kinghorni* size classes (Covacevich & Couper, 1991), as well as the ability of this snake to maintain high population densities in suitable habitat (Fearn et al., 2005). Intuitively, the introduction of an apex predator into an ecosystem would have significant impacts. However, without detailed quantitative, base line data on the distribution and abundance of potential prey species and possible competitors, such impacts may be impossible to detect and quantify. The potentially devastating impact of introduced ophidian predators is demonstrated by brown tree snakes, *Boiga irregularis* (Colubridae) on the Pacific Island of Guam (extensive data summarised in Rodda *et al.*, 1999). To determine the true status of the Airlie Beach population, we suggest that tissue samples be collected from Airlie Beach/Conway Range *M. kinghorni* to determine the degree of relatedness in this population as well as to identify possible genetic affinities with Wet Tropics populations.

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Kelly, Maree Glossat, Ray and Ashley Field, Scott Sullivan and Mike Pople of the Queensland Parks and Wildlife Service, Dr Lin Schwarzkopf and Laurie Daniels.

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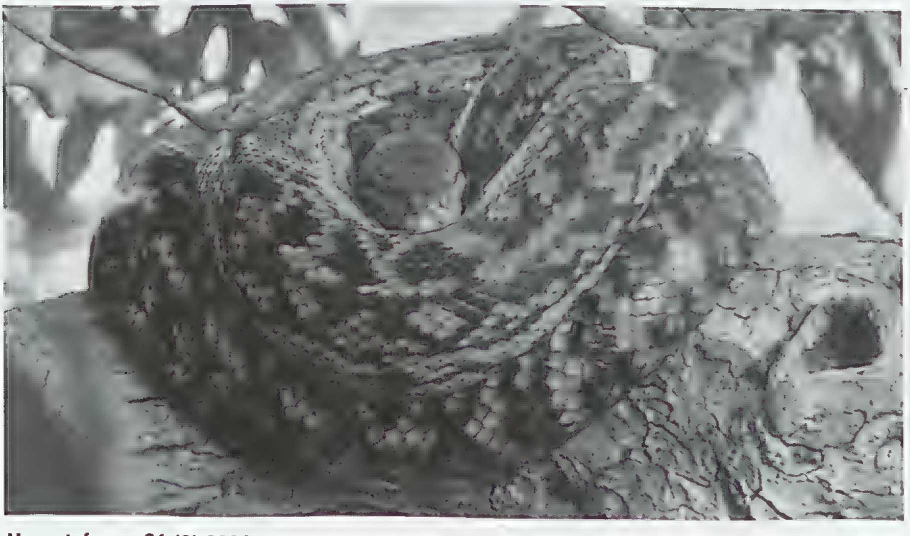
Figure 1. A large adult *Morelia kinghorni* basking in a tree at Brandon, north east Queensland. Photo courtesy of Beatty Kelly.



COMMUNAL EGG-LAYING IN *LAMPROPHOLIS COGGERI* AND *SAPROSCINCUS TETRADACTYLA* (SCINCIDAE)

Grant Turner
PO Box 2035, Innisfail, Qld 4860.

INTRODUCTION

Lampropholis coggeri and *Saproscincus tetradactyla* are small (SVL 41, 33 mm respectively) terrestrial skinks that are endemic to the Wet Tropics region of north Queensland and whose biology is poorly known (Cogger, 2000: 576; Wilson, 2005: 55). No information is available on any aspect of reproduction in *L. coggeri* and only limited information is available on clutch size for *S. tetradactyla* (Greer & Kluge, 1980; Ingram, 1990). Below I describe the occurrence of eight relatively small communal nests: five nests containing *S. tetradactyla* eggs only and three nests containing the eggs of both species.

METHODS

All observations occurred in a small rain-forested gully at Upper Daradgee, 18 km west of Innisfail (17°32'S 146°01'E), north Queensland over the period September 2005 through April 2006. Habitat was an approx. 70 m-wide strip of mesophyll vine forest (Tracey, 1982: 113) on red clay soils with numerous, mostly small (<0.40 m diameter) basalt stones, abundant leaf litter and some small rotting logs. Eggs were located by turning ground cover. The maximum length and width of rocks below which eggs were located was measured with a flexible tape measure (±0.5 cm). While I use the term 'nest' below for convenience this does not imply any construction on the part of skinks except perhaps in a few instances where an existing ground cavity may have been slightly enlarged to accommodate eggs; otherwise the term simply refers to the location where eggs were laid. Eggs typically occurred in clusters and those from the same clutch sometimes adhered to each other. Sample eggs from each cluster within nests were removed for artificial incubation to confirm species identity. Eggs were placed in small cardboard boxes (9.5 x 7.5 x 3.0 cm) containing a 1 cm layer of damp clay soil and the boxes were placed in the drawer of a stainless-steel cabinet located outdoors undercover a short distance from the nest sites. They were checked daily and mist-sprayed every few days to prevent dehydration. Hatching dates were recorded and the period over which sampled eggs from a single nest hatched was determined (referred to as the 'hatching period'). Hatchlings were released at nest sites within 24 hrs of emerging.

The number of clutches within nests was estimated using the limited information available on clutch size in both species. *Saproscincus tetradactyla* appears to have a clutch size of two eggs (n = 2 with oviductal eggs; Greer & Kluge, 1980; n = 5; Greer, 1989: 179). I captured five gravid females and each had two eggs clearly visible through their translucent abdomens. No published information on clutch size is available for *L. coggeri*; however, I captured gravid females containing two (n = 2) and three (n = 2) eggs. The species is one of the smallest in the genus, for which the maximum recorded clutch size is seven (Greer, 1989: 178) and so a maximum clutch size of five and a minimum of two is assumed, although the interpretations below are not significantly altered should maximum clutch size be larger.

OBSERVATIONS

Saproscincus tetradactyla was found to nest singly and also communally whereas *Lampropholis coggeri* eggs were only located in communal nests. In all instances, eggs were deposited beneath stones on clay substrates, were not buried, but were sometimes deposited in soil cavities. The stones used as com-

munal nest sites did not appear to be different in size, position or substrate characteristics from nearby stones.

Saproscincus tetradactyla nests

These nests are detailed in Table 1. The number of clutches in a single nest was small, ranging from two to six. In all instances egg clusters were within 2 cm of each other. The hatching period varied from 7 - 16 days. In two instances, gravid female *S. tetradactyla* were located beneath stones near egg clusters. Two nests of four eggs (representing two clutches) were located but eggs were deposited in separate clusters more than 5 cm apart. A total of ten single clutches of two *S. tetradactyla* eggs and three nests of only single eggs were also found.

Mixed-species nests

These nests are detailed in Table 2 and below. They consisted predominantly of *L. coggeri* eggs with only one or two clutches of *S. tetradactyla* eggs. The hatching period spanned 22 - 28 days.

Nest 1: This nest was situated beneath a stone lying on flat ground. It consisted of two clusters of nine and seven eggs respectively that were 7 cm apart. Eggs within clusters were all in direct contact with each other. A gravid female *S. tetradactyla* was located on top of the smaller cluster. Artificially incubated eggs comprised seven *L. coggeri* and one *S. tetradactyla* (from the smaller cluster).

Nest 2: This nest, the largest located, contained 25 eggs (Figure 1). They were found beneath a stone partially imbedded on sloping ground. A 'loose' cluster of 14 eggs (far left of Figure 1) was situated at the bottom of the slope. Half of the eggs were in a soil cavity in direct contact with each other, while the remainder were only 1-2 cm apart. Another three clusters, two of three eggs and one of five eggs were situated within 5 cm of each other. Artificially incubated eggs comprised eight *L. coggeri* and two *S. tetradactyla* (from two different egg clusters).

Nest 3: This nest occurred beneath a partially embedded stone on sloping ground. It comprised two clusters of eggs that were 2 cm apart: one of two eggs and another of seven eggs all in direct contact with each other. Artificial incubation revealed that the smaller cluster contained *S. tetradactyla* eggs and the larger cluster was comprised of *L. coggeri* eggs.

DISCUSSION

Communal egg-laying has been recorded in several species of *Lampropholis* and *Saproscincus* (German, 1989; Greer, 1989: 127; Ehmann, 1992: 258; Couper & Schneider, 1995) and so the occurrence of communal egg-laying in other members of these genera is not surprising. Communal egg-laying in *S. tetradactyla* is weakly developed compared to congeners (up to 142 eggs in *S. mustelinus*; German, 1989), with relatively small numbers of clutches occurring together (≤ 6). The same is also true of *L. coggeri* which has small communal nests when compared to other communal egg-laying congeners like *L. delicata* and *L. guichenoti*, that are known to deposit hundreds of eggs at a single nest site (Wells, 1979, 1981).

Mixed species communal nests have been recorded previously between *Nannoscincus maccoyi* and *Lampropholis delicata* (Pengilley, 1972), *L. delicata* and *L. guichenoti* (Wells, 1981), *L. delicata* and *Saproscincus mustelinus* (Shea & Sadlier, 2000) and *Bassinia platynota* and *L. guichenoti* (Doody, 2006). In these instances it is not stated whether the species involved laid their eggs in separate clumps or together, but in the case of *L. coggeri* and *S. tetradactyla* examples of both were seen. The single clutch of *S. tetradactyla* eggs in nest 3 (Table 2) may have no real association with the *L. coggeri* eggs given they occurred in separate clumps. In nests 1 and 2 however, *S. tetradactyla* eggs were laid in amongst and on top of *L. coggeri* eggs. The tendency for species to lay eggs in mixed communal nests may reflect an inability of females to discriminate between the eggs of their own and other species.

Several discoveries of communal skink nests have reported that sampled eggs hatched within a short time period (24-48 hrs; Mitchell, 1959; Wilhoft, 1963; Couper & Schneider, 1995) suggesting that eggs were all laid at approximately the same time. The results for *S. tetradactyla* and *L. coggeri* clearly indicate that egg-laying (and therefore hatching) is asynchronous, occurring over a period spanning one to four weeks. The longer hatching times for the mixed communal nests compared to the *S. tetradactyla* nests may simply be a function of the greater number of clutches in these nests. Shea & Sadlier (2000) reported the hatching of sampled eggs occurred over approximately three weeks in two communal nests.

Communal nesting in Australian tropical skinks has not been commonly reported in the literature (Silbertschmidt & Goodman, 2003) and this is probably a consequence of the lack of field work conducted in the region rather an absence of this habit among oviparous tropical skinks. Occurring in sympatry with *L. coggeri* and *S. tetradactyla* are *Carlia rubrigularis* and *S. basiliscus* and both species are widespread throughout much of the southern lowland Wet Tropics region (pers.obs.). Despite having spent considerable time searching ground cover in rainforest, I have only located two clutches of *S. basiliscus* eggs and one clutch of *C. rubrigularis* eggs (all beneath stones). Wilhoft's (1963) study of *C. rubrigularis* (in the Innisfail region) also commented on the failure to find the species' eggs in rainforest but he did manage to locate three (small communal) nests near a human dwelling in a large pile of humus. This indicates that differences exist in nest sites chosen by *L. coggeri* and *S. tetradactyla* compared to *S. basiliscus* and *C. rubrigularis*.

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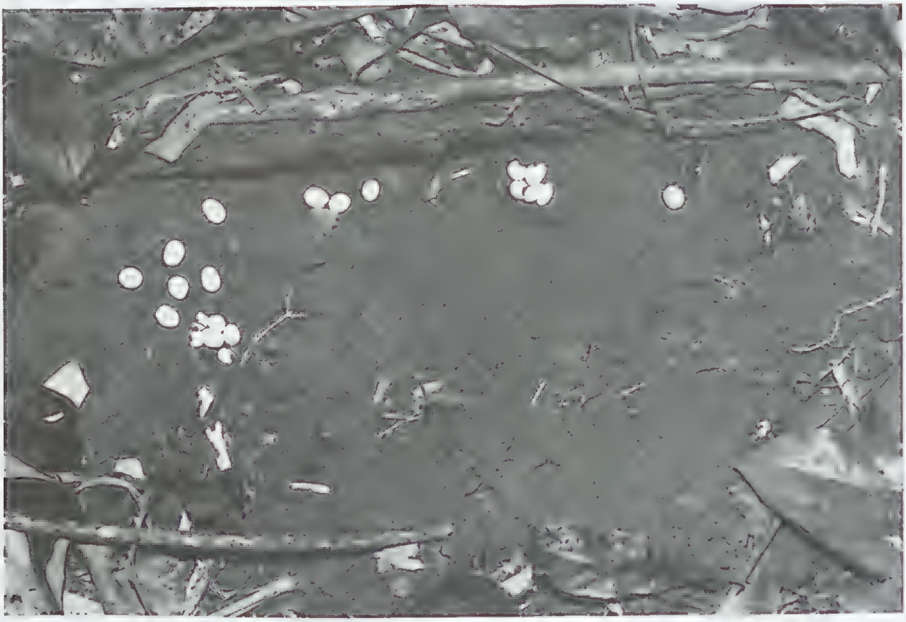
Table 1. Details of five nests containing multiple clutches of *Saproscincus tetradactyla* eggs.

No.	Date	Rock Size (cm)	No. of Eggs (no. sampled)	No. of Clusters	No. of Clutches	Hatching Period (days)
1	23.10.05	30.5 x 27	6 (3)	2	3	16
2	4.11.05	30.5 x 21	8 (4)	3	4	12
3	26.11.05	66 x 52.5	11 (4)	2	5 or 6	12-15
4	19.03.06	34 x 31.5	4 (3)	1	2	14
5	14.04.06	39 x 28.5	4 (2)	1	2	7

Table 2. Details of three nests containing multiple clutches of *Lampropholis coggeri* and *Saproscincus tetradactyla* eggs. LC = *L. coggeri* and ST = *S. tetradactyla*.

No.	Date	Rock Size (cm)	No. of Eggs (no. sampled)	No. of Clusters	No. of Clutches		Hatching Period (days)
					LC	ST	
1	23.10.05	33.5 x 24.5	16 (8)	2	3-7	1	26
2	23.10.05	32 x 15	25 (11)	4	4-9	2	28
3	18.02.06	30.5 x 21	9 (4)	2	2-3	1	22

Figure 1. A mixed communal nest of *Lampropholis coggeri* and *Saproscincus tetradactyla* eggs containing a total of 25 eggs (not all visible; Table 2, Nest 2)



A TRIAL USING SALT TO PROTECT GREEN AND GOLDEN BELL FROGS FROM CHYTRID INFECTION

A.W. White
Frog Ecology and Behaviour Group, Australian Museum, 6 College Street, Sydney, 2001.

INTRODUCTION

Chytridiomycosis (chytrid) is a highly infectious disease that has been implicated in the decline of several Australian frog species and frog populations (Berger *et al.*, 1998). The first authenticated cases of chytrid in Australia occurred in the 1970s and the disease has subsequently been detected in more than 70 species of Australian frogs (Berger *et al.*, 1999a). Although the disease has apparently been present in Australia for over thirty years, a reliable detection method for the disease was not developed until 1995 (Berger *et al.* 1999b). Treatments for infected frogs and tadpoles are currently being tested. The spread of chytrid through many frog populations has gone unchecked and until now no attempts have been made to protect frog populations in the field.

Investigations into the nature of chytrid transmission indicated that small, non-motile spores borne in water or on moist surfaces are the means of spread of the pathogen. Tests have been carried out to determine the viability of chytrid spores under a variety of environmental and experimental conditions. Spores appear to be viable within only a narrow temperature range, are easily killed by desiccation or UV exposure and are very susceptible to many fungicides and bactericides (Berger *et al.*, 1999b; Longcore, 2001; Marantelli & Berger, 2001). In 2000, it was suggested (Berger, pers. comm.) that table salt (NaCl) could also kill or inactivate chytrid spores. Chytrid has not been detected in frog populations that occur in mangrove or saline areas but this could be due to lack of survey effort rather than to any fungicidal actions of salt.

This paper describes a trial to protect an urban population of Green and Golden Bell Frogs *Litoria aurea* from chytrid using salt (White, 2001).

MARRICKVILLE GREEN AND GOLDEN BELL FROG PROJECT

In 1997, a pond site was selected in the inner-suburban suburb of Marrickville in Sydney. This site was chosen to be the location of a captive bred population of *L. aurea* and was designed to determine if this species could be conserved as "back-yard" animals. The decision to trial small ponds in urban settings was considered warranted as populations of this species were still declining in "natural" areas but persisting in some disturbed or artificial habitats (see Pyke & White, 2001).

In late 1997, a 3 metre diameter pond was constructed in the ground of the Marrickville Community Nursery. An area of 100 m^2 was enclosed in frog-proof fence and in February 1998; 22 *L. aurea* tadpoles captive-bred at Taronga Zoo were released into the pond. Staff and helpers followed simple frog hygiene procedures when entering the area of the pond; these included only using the same boots for this site, always using new holding bags and sterilizing equipment that may have been used for field surveys in other areas.

Tadpoles were caught and measured on a weekly basis and observations were taken on their growth rates and behavior. Some tadpoles were eaten by kookaburras and some were killed by aquatic insects, none died of disease or starvation. By late April 1998, 14 young frogs were present in the pond. Measurements of their growth rates were recorded intermittently over the next three years. Calling by male frogs were first heard in August 1998 but no breeding occurred that season; an inspection of the female frogs revealed that none became gravid during that period. During the summer of 1998/1999 two frogs were killed by Black Rats, another was seriously injured by a rat and another was killed when it escaped the enclosure.

In February 1999, 100 *L. aurea* tadpoles were released into the pond. Some of these were eaten by the adult frogs resident in the pond, however, 84 survived to become juvenile frogs. Predation of juvenile frogs by adult frogs was quite high and by May 1999 only 24 juveniles remained alive.

In November 1999, the first breeding occurred in the pond. The number of adult frogs in the pond was now 27 and predation of the tadpoles and juvenile frogs was again high.

CHYTRID OUTBREAK

In April 2000, Marrickville Council undertook some repairs to the Community Nursery that entailed taking down some of the frog-proof fence. Within ten days, Striped Marsh Frogs *Limnodynastes peroni* were found in the pond. In early May 2000, the first dead Bell Frogs were found (Figure 1). The carcasses were collected and forwarded to Taronga Zoo for autopsy revealing that all had died from chytrid. No dead Striped Marsh Frogs had been found so live Striped Marsh Frogs were also collected from the pond and sent to be tested. These apparently healthy frogs tested positive for chytrid (K. Rose, pers. comm.).

By the end of June 2000 only one *L. aurea* was alive in the pond, the rest had succumbed to the disease. In November 2000, at the "Chytrid Conference (Getting the Jump! on Amphibian Disease)" held in Cairns, it was suggested (Berger, pers. comm.) that chytrid spores were sensitive to table salt and may be killed or inactivated by it. The concentration of salt required to achieve this result had not been determined but was thought to be about 0.5 % NaCl.

THE FUTURE OF AN INFECTED POND

A decision had to be made regarding the future of the Marrickville frog pond. The pond could be cleaned out and sterilized and prepared for a new introduction of *L. aurea* tadpoles, or this disaster could be an opportunity to test the power of salt to curtail chytrid in ponds. Bell Frog tadpoles and adult frogs (Penman, 1999; Christie & Dickman, 2002) have some tolerance of salinity and Bell Frogs are often found in mangrove areas or near sea shores (Pyke & White, 2001). Tadpoles are able to tolerate salinity of up to 5% sea water (i.e. 1.7 ppt) before there are any apparent effects on growth and maturation rates (Penman, 1999). Adult frogs may tolerate 8% sea water for short duration (Christie & Dickman, 2002).

It was decided to treat the Marrickville pond with salt and raise the salinity up to 3% sea water (i.e about 1 ppt NaCl). In December 2000, uniodised table salt was added to the pond until a uniform concentration of about 1 ppt was achieved (as measured using a Yeokal Portable Meter). The pond was checked each week and the salinity adjusted to as close to 1 ppt as possible.

Figure 1. Green and Golden Bell frogs that died from chytrid were often found dead in exposed locations.

Table 1. Summary of Tadpole Release Data

	February 1999 Release	February 2000 Release	December 2000 Release
Age at Time of Release	24 days	27 days	25 days
Age at Appearance of First Metamorphs	43 days	43 days	49 days
Age at Appearance of Last Metamorphs	76 days	80 days	123 days

RELEASE OF BELL FROG TADPOLES

In December 2000, the frog-proof fence was reinstated and 40 captive-bred Bell Frog tadpoles (stages 24-25) were released into the pond. The tadpoles were measured at weekly intervals and the first juvenile frogs were found in late January 2001. By the end of February 2001, all of the tadpoles had metamorphosed and 33 juvenile frogs were present in the pond. Two tadpoles were eaten by adult Striped Marsh Frogs, the fate of the five unaccounted-for tadpoles remains unresolved.

Growth of the tadpoles in 3 % sea water pond appeared slower than that recorded for tadpoles in fresh water (Table 1). This was hard to quantify as the tadpoles, although always from a single spawning event, were not all the same stage when they were released. Similarly, although salt levels were controlled in the pond, other water parameters may have been different during the study period. Further comparisons are probably invalid as survival rates were very different as there was cannibalism of tadpoles during the second and third releases.

The juvenile Bell Frogs continued to grow and periodically were seen swimming in the pond. Predation of the young Bell Frogs occurred as Striped Marsh Frogs were still in the ponds and within the enclosure. No chytrid-affected Bell Frogs were found during the period from the end of March until June 2001. If chytrid was still active in the pond, it was expected that most (or all) of the tadpoles would have been affected and most would have died at metamorphosis.

As no chytrid deaths occurred, it was decided to catch some Striped Marsh Frogs to see if they were still infected. Two Striped Marsh Frogs were sent to Taronga Zoo; chytrid could not be detected in either frog (K. Rose, pers. comm.).

IMPLICATIONS ARISING FROM THE TRIAL

Although the salt treatment of the pond was an unreplicated and uncontrolled experiment, the outcome may be highly significant. If, as it appears, low concentrations of salt can be used to protect Bell Frogs in certain environments, a simple management tool may be available to help conserve an endangered frog species. This trial did not extend long enough to determine if the salt levels in the pond suppressed breeding by Bell frogs or interfered in other aspects of their life.

Studies of *L.aurea* at Broughton Island reveal that these frogs can breed in ponds abutting the sea platform that receive salt spray and periodic inundation by waves. If salt levels are above 5-8% sea water, tadpoles in the pond eventually die (Pyke & White, unpublished data). In some ponds it was observed that salt layering occurred and more saline water was found in the deeper levels of the ponds. Bell Frog tadpoles, scared into diving to the bottom of these ponds, quickly returned to the fresher, upper layers despite the presence of a threat. At Broughton Island, *L. aurea* breed in salt-affected ponds but the salt concentrations in these ponds is not static and changes in response to rain, sea spray and evaporation.

Breeding by Striped Marsh Frogs did not occur in the Marrickville pond after the addition of salt to the water. In addition, calling by these frogs occurred less frequently and the number of adult Marsh Frogs around the pond on any night was lower than when the water in the pond was fresh.

It is not possible to know whether the salt treatment protected Bell Frogs by killing chytrid spores or by disinfecting the infected Striped Marsh Frogs. If salt kills the spores, it may be possible to pre-treat water used in frog ponds with salt and later desalinize the water so that salt-sensitive frog species are able to use the water. Similarly, it is not known how long a frog would need to be exposed to the salty water to be effectively disinfected. Another possible explanation for the results is that chytrid was already inactive before the addition of salt and tadpoles into the pond.

The concentration of salt required to effectively kill chytrid spores has not been rigorously tested but recent tests indicate that the concentration may be higher than originally suspected. Concentrations of up to 5% were required to kill chytrid spores in 2004 laboratory trials (R. Speare, pers comm.).

ACKNOWLEDGMENTS

The Marrickville Project would not have been possible without the help of many people. Marrickville City Council made available the Nursery site for the location of the pond. Council staff, notably Stefanie Pillora, Melanie Halliday, Jenny Kirk, Helen Knowles and members of the Friends of the Green and Golden Bell Frog Group, especially Wendy, Swapan Paul and Tracey White. The Georges River Catchment Management Committee made the funds available to excavate and install the pond while Taronga Zoo provided the Green and Golden Bell frog tadpoles for the experiment. Taronga Zoo veterinary staff (especially Kari Rose) were very helpful in testing frogs and tadpoles for chyrid. The project was licensed by the NSW National Parks and Wildlife Service.

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POTENTIALLY FATAL INGESTION OF PREY BY THE GREEN-EYED TREE FROG (*LITORIA GENIMACULATA*)

Jodi J.L. Rowley
School of Tropical Biology, James Cook University, Townsville, Qld 4811.
Email: Jodi.rowley@gmail.com.

INTRODUCTION

In captivity, many amphibian species exhibit a strong feeding response that may result in the ingestion of very large prey items (Fleay, 1935; Wright & Whitaker, 2001). This feeding response may result in the rapid mortality of the amphibian due to the animal being unable to respire effectively or from toxins produced by the rotting, undigested food (Wright & Whitaker, 2001). Although fatal and near-fatal ingestion of prey has been reported in the wild for snakes (Fitch, 1949; Mulcahy *et al.* 2003; Pauly & Benard, 2002; Powell *et al.*, 2004; Turner, 2001), to date it has only been reported in captive frogs (Wright & Whitaker, 2001). Here I report a potentially fatal ingestion of a prey item in the rainforest stream hylid *Litoria genimaculata*.

OBSERVATION

This observation occurred during a radio-tracking study being carried out at Kirrama State Forest, North Queensland. The particular frog was an adult female *L. genimaculata*, measuring 58.6 mm snout-vent length and weighing 12 g. On 5 March 2004, a small radio-transmitter was fitted to the frog externally with a waist-belt made of silicon tubing.

At 2020hr, on 11 March 2004, the frog was found exposed on a dry rock in a streambed, with a large orthopteran (Suborder Ensifera; Family Gryllacrididae) protruding from its open mouth (Figure 1). The frog was located again at 1345 hr the next day, and was sitting exposed on another rock approximately 2 m away, with the cricket still projecting from its mouth. A closer visual inspection found no evidence of movement in the frog and it was presumed dead, and ants were crawling in and around its mouth. However, once I handled the frog, I realised that it was still alive, and removed the orthopteran (Figure 2). The frog was lethargic, and did not move when it was placed back on the rock. When located at 1920 hr that evening, the frog had moved only 0.1 m, but by the next day the frog had moved over 10 m and had climbed terrestrial vegetation. Tracking of this frog continued for several days, whereby the frog resumed typical behaviour.

DISCUSSION

It is probable that, without intervention, the frog would have died due to the partial ingestion of such a large prey item. It is highly unlikely that the frog would have been able to digest the prey, leading to the frog being poisoned by the decomposing prey. In addition, during this observation, the frog remained largely immobile in a conspicuous, exposed position, rendering it vulnerable to predation. It is clear that the frog was unable to move in order to avoid the ants crawling in and around its mouth. Such behaviour is highly uncharacteristic for the species (Rowley, unpubl. data).

Decreased mobility or immobility has been reported occurring in snakes for a number of days after ingesting large prey items (Fitch, 1949; Pauly & Benard, 2002; Turner, 2001). Immobility in unfavourable environmental conditions or inability to escape from predators appears to have caused the mortality of snakes in these instances, and would have been a risk for the frog observed in this study. Although the ingestion of large prey items may occur without any adverse effects (Fleay 1935), this observation demonstrates that attempting to ingest large prey items is not without substantial risk.

It is highly unlikely that the transmitter or waist-belt influenced the behaviour of the frog or the outcome of attempting to ingest such a large prey item. The waist-belt was tied loose and very low, so that it did not interfere with the frog's ability to ingest prey. Rather, the prey item was so large (almost as long as the frog) that it could not fit inside the gut of the frog without protruding from the mouth.

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Figure 1. Large orthopteran projecting from the mouth of a female *Litoria genimaculata.*

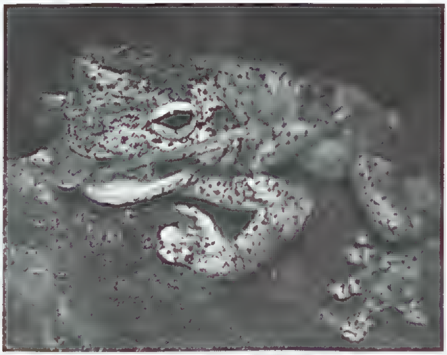

Figure 2. Body size comparison of orthopteran prey and the female *Litoria genimaculata* after removal of prey from the frog.

ADDITIONS TO THE HERPETOFAUNA OF THE ROCK NATURE RESERVE NEAR WAGGA WAGGA, NEW SOUTH WALES

Michael J. Murphy and Sam Murphy
'Blackbird Grange', 2 Rundle Street, Coonabarabran, NSW 2357.

The Rock Nature Reserve (35°16'S 147°04'E) is located about 30 km south-west of Wagga Wagga, in Wiradjuri Aboriginal Country in the NSW South Western Slopes IBRA bioregion. The Reserve is 341 ha in area and comprises a steep rocky ridge of Devonian quartzite and slate with an elevation range of 210-554 m AHD. The lower slopes support woodland dominated by Grey Box *Eucalyptus microcarpa*, Yellow Box *E. melliodora*, White Box *E. albens*, Blakely's Red Gum *E. blakelyi* and White Cypress Pine *Callitris glaucophylla*, while higher slopes and ridge tops support woodland of mainly White Box, Dwyer's Mallee Gum *E. dwyeri*, Currawang *Acacia doratoxylon* and Hill Oak *Allocasuarina verticillata* (Burrows, 1999). Valuable microhabitats available for reptiles include rock outcrops, trees with decorticating bark, fallen timber and leaf litter. Breeding habitat for frogs is limited but includes a small dam on the lower slopes of the reserve and shallow ephemeral pools which form in depressions following heavy rain.

Previous targeted surveys of herpetofauna in The Rock Nature Reserve by Caughley and Gall (1985), Bos and Lockwood (1996) and Daly (2004) recorded a total of only three frog and 11 reptile species. A search of the Atlas of NSW Wildlife database (on the NSW National Parks and Wildlife Service website www.nationalparks.nsw.gov.au) in November 2006 provided records of another two frog and three reptile species for The Rock Nature Reserve, although it should be noted that the reliability of these records is unknown.

Opportunistic observations of frogs and reptiles were made during the course of a field study of the woodland bird community of The Rock Nature Reserve between 1995 and 2006 (Murphy, in press). Ten species of herpetofauna were recorded, including three frog and two reptile species not reported by any of the previous targeted surveys. An updated list of herpetofauna for The Rock Nature Reserve from all of the above sources is provided in Table 1 below. The herpetofauna reflects the location of the reserve in the transitional zone between coastal Bassian and arid Eyrean faunal assemblages (Caughley & Gall, 1985). Bassian species recorded include the Eastern Banjo Frog *Limnodynastes dumerilii*, Copper-tailed Skink *Ctenotus taeniolatus* and Southern Lerista *Lerista bougainvillii*. Eyrean species include the Marbled Gecko *Christinus marmoratus*, Sand Goanna *Varanus gouldii* and Boulenger's Morethia *Morethia boulengeri*.

An adult Inland Carpet Python *Morelia spilota metcalfei* of at least 250 cm total length was observed in The Rock Nature Reserve by the authors in January 1999, the first documented record of this species in the Reserve. The animal was seen at dusk, lying on top of a hollow fallen log in Box woodland on the lower slopes of the Reserve and was photographed *in situ* (Fig. 1). The Inland Carpet Python is a species of serious conservation concern in inland NSW, with evidence indicating a considerable decline over the last century and low current population densities (Shine, 1994). The confirmed occurrence of this species in The Rock Nature Reserve is a noteworthy addition to the documented conservation values of the Reserve.

Many reptile species have cryptic habits and/or occur at low population densities, and are thus difficult to detect without considerable survey effort (or good fortune). Woinarski *et al.* (2000) noted that snakes in particular are typically under-sampled in standard systematic surveys. Broad-scale regional surveys

such as those by Caughley and Gall (1985), Bos and Lockwood (1996) and Daly (2004) can provide a useful regional overview but, with limited survey effort per site, can be expected to underestimate the species richness of individual sites. The extent of underestimation can be demonstrated by comparing their results with local-scale surveys where a greater survey effort could be expended per site. Caughley and Gall (1985) recorded an average of nine reptile species per site (range 1-16, n = 12) and concluded that the central forests of the NSW South Western Slopes had only a depauperate herpetofauna. Daly (2004) also recorded an average of nine reptile species per site (range 1-20, n = 16). In contrast, a local-scale survey in the Wagga Wagga area by Sass (2003), with 50 hours search effort per site, recorded an average of 17 reptile species per site (range 10-25, n = 6). Furthermore, while neither Caughley and Gall (1985) or Daly (2004) detected the regionally significant Inland Carpet Python at any of the sites they surveyed (including The Rock Nature Reserve), Sass (2003) recorded it at half of the sites surveyed. The results of broad-scale regional surveys need to be interpreted with caution.

It is unlikely that the species list presented here represents the complete herpetofauna of The Rock Nature Reserve. Additional species likely to be found there, based on consideration of available habitats and accounts of the herpetofauna occurring in the Wagga Wagga area (including Caughley & Gall, 1985; Annable, 1995; Healey *et al.*, 1997; Murphy, 1997; Sass, 2003 and Daly, 2004) include the Common Spadefoot Toad *Neobatrachus sudelli*, Eastern Stone Gecko *Diplodactylus vittatus*, Thick-tailed Gecko *Underwoodisaurus milii*, Jacky Lizard *Amphibolurus muricatus*, Southern Rainbow Skink *Carlia tetradactyla*, Striped Skink *Ctenotus robustus*, Common Dwarf Skink *Menetia greyii*, Eastern Blue-tongue *Tiliqua scincoides*, Prong-snouted Blind Snake *Ramphotyphlops bituberculatus* and Eastern Bandy-bandy *Vermicella annulata*.

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Table 1. List of herpetofauna species recorded in The Rock Nature Reserve.

Source of record: 1 = Caughley and Gall (1985), 2 = Bos and Lockwood (1996), 3 = Daly (2004), 4 = NPWS Atlas of NSW Wildlife (2006), 5 = the authors. Taxonomy follows Barker *et al.* (1995) and Swan *et al.* (2004).

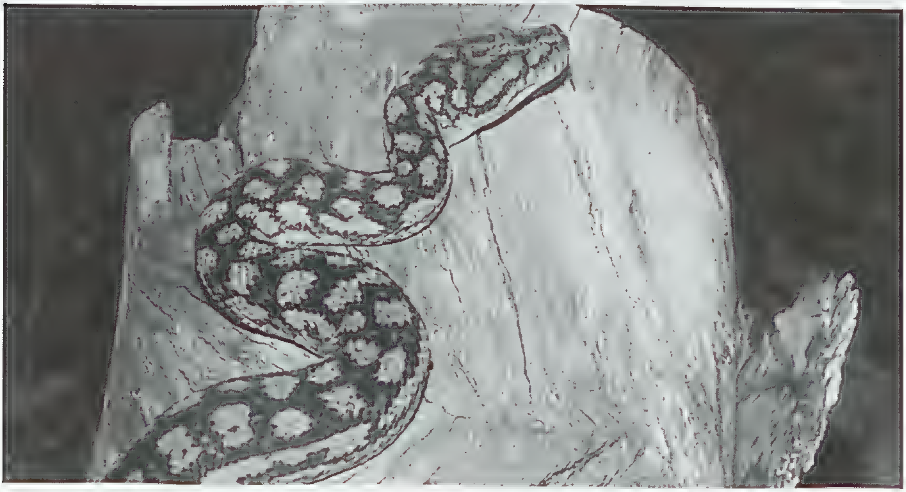
Amphibia

Litoria peronii Peron's Tree Frog[5]
Crinia parinsignifera Plains Froglet[5]
Crinia signifera Common Froglet[4]
Crinia sp. Undetermined Froglet species[1]
Limnodynastes dumerilii Eastern Banjo Frog[4]
Limnodynastes interioris Giant Banjo Frog[1,4]
Limnodynastes tasmaniensis Spotted Marsh Frog[1,4]
Uperoleia rugosa Wrinkled Toadlet[5]

Reptilia

Christinus marmoratus Marbled Gecko[1,4]
Strophurus intermedius Southern Spiny-tailed Gecko[1,4]
Varanus gouldii Sand Goanna[1,4]
Varanus varius Lace Monitor[1,4,5]
Amphibolurus nobbi Nobbi Dragon[3,4,5]
Pogona barbata Eastern Bearded Dragon[4,5]
Lialis burtonis Burton's Legless Lizard[1,2,4]
Cryptoblepharus carnabyi Carnaby's Skink[1,3,4,5]
Ctenotus taeniolatus Copper-tailed Skink[4]
Egernia striolata Tree Skink[2,3,4,5]
Lerista bougainvillii Southern Lerista[3,4]
Morethia boulengeri Boulenger's Morethia[1,3,4,5]
Morelia spilota metcalfei Inland Carpet Python[5]
Pseudonaja textilis Eastern Brown Snake[2,3,4]
Suta dwyeri Dwyer's Black-headed Snake[4]

Figure 1. Inland Carpet Python (*Morelia spilota metcalfei*) on lower slopes of The Rock Nature Reserve, January 1999. (Photo: M. Murphy).



DESCRIPTION OF BREEDING SITES OF THE GIANT BURROWING FROG *HELEIOPORUS AUSTRALIACUS* IN SOUTH-EASTERN NSW

Trent Penman[1,2], Francis Lemckert[1,2], Chris Slade[3] and Michael Mahony[1]
[1] School of Environmental and Life Sciences, University of Newcastle, NSW 2308.
[2] Forest Biodiversity, Forests New South Wales, PO Box 100, Beecroft, NSW 2119.
[3] Southern Region, Forests New South Wales, 13 Bass St, Eden, NSW 2551.
Email for corresponding author: trentp@sf.nsw.gov.au.

ABSTRACT

Heleioporus australiacus is a large threatened frog species in south-eastern Australia. Little is known about the breeding habitat requirements of the southern populations of this species. It may have specific breeding habitat requirements and therefore the availability of breeding habitat may be significant in determining its distribution. We describe the habitats of a number of known breeding sites in the Eden area. It was found to breed in pools within first and second order streams and in artificial pools, all within dry forest areas. These habitats appear to be widespread throughout the region, and it is therefore unlikely that the availability of breeding habitat is limiting its distribution there.

INTRODUCTION

The giant burrowing frog, *Heleioporus australiacus* Shaw and Nodder, is a large threatened frog species in south-eastern Australia. The species is listed as vulnerable under Australian Commonwealth legislation, the *Environmental Protection and Biodiversity Conservation Act* 2000, in New South Wales under the *Threatened Species Conservation Act* 1995 and threatened in Victoria under the *Flora and Fauna Guarantee Act* 1988. Listing of this species has occurred primarily due to a lack of records resulting in a poor understanding of the ecology of the species (Tyler, 1997; Lunney *et al.*, 2000; Penman *et al.*, 2004).

Records of *H. australiacus* extend from Singleton, NSW in the north to approximately 120 km east of Melbourne in the south (Penman *et al.*, 2004). A disjunction occurs on the south-coast of NSW between Ulladulla and Narooma (Lemckert *et al.*, 1998). This gap has led several authors to suggest that the northern and southern populations may represent two distinct species (Gillespie, 1990; Daly, 1996). If this is the case, then there may be differences in the habitat requirements between the two populations (Penman *et al.*, 2004).

There are relatively few records of breeding throughout its range (Penman *et al.*, 2004). Records of breeding from the northern populations have been from hanging swamps and ponds forming within sandstone based creeks (Harrison, 1922; Mahony, 1993; Daly, 1996; Rescei, 1996) and in coastal heath commonly associated with *Gleichnia dicarpa* and *Gahnia* spp. (Littlejohn & Martin, 1967; Daly, 1996; White, 1999). There are few records of breeding from the southern populations (Penman *et al.*, 2004). Where breeding has been recorded, it has been from fire dams or in small creeks (Littlejohn & Martin, 1967; Gillespie, 1990). The species may have specific breeding habitat requirements and the availability of breeding habitat therefore may be significant in determining the distribution of this species.

This paper describes a number of breeding sites used by *H. australiacus* in south-eastern NSW representing the first breeding sites identified in south-eastern NSW. We use this information to compare data from Victorian breeding sites and assess whether breeding sites are likely to be a limiting factor for this species, which could in turn account for its rarity in this area.

METHODS

The study was conducted in the Nullica State Forest in south-eastern NSW approximately 10 km north of Eden (37°02'S 149°54'E). The area is generally classified as lowland dry shrub forest, with the wetter gully areas being classified as hinterland wet shrub forest (Keith & Bedward, 1999). These forests are open coastal forests dominated by red bloodwood (*Corymbia gummifera*), blackbutt (*Eucalyptus pilularis*) and blue stringybark (*E. agglomerata*).

Breeding sites were identified during a long-term radio-tracking study of the species (Penman, 2005; Penman *et al.*, 2006). When an individual moved to a potential breeding site, additional surveys were conducted to determine if breeding activity had occurred. These surveys were auditory (to assess calling behaviour) and tadpole surveys (to assess the existence of a breeding event). Tadpoles were identified using Anstis (2002). No egg masses were observed. The following habitat measurements were taken for each breeding site: the dimensions of the pool, its maximum depth, and stream order (as defined by Strahler, 1952), shading by canopy and understorey species was estimated visually, and the nature of the base of the stream/pool and the nature of the stream/pool edge described, i.e. rock, vegetation, leaf litter or bare earth. The small number of known breeding sites meant that any meaningful statistical analysis of the data was not possible.

RESULTS

Only four of the 13 adult females and 10 of the 19 adult males tracked were observed entering a breeding site. In total, 14 frogs undertook 15 migrations into potential breeding sites between February and April, and once in October 2002. Individuals spent very little time there, ranging from one to 12 days (mean 5.00 days, n = 15). Migrations were always associated with rainfall events, moving on the night of or within ten days of more than 20 mm rainfall (Eden rainfall station, Bureau of Meteorology).

Six different breeding sites (sites where calling frogs or tadpoles were recorded) were identified. Four were natural watercourses and two were ponds that have developed as a result of the construction of forest roads. The breeding sites were all semi-permanent (i.e. held some water in all but the driest periods), with stream flows occurring only after heavy rainfall events; significant flows ceased shortly after. The artificial ponds did not flow at any time during the study.

On the streams breeding occurred in small pools, but the majority of the tadpoles were located in larger, deeper pools 10 - 50 m downstream. Descriptions for each breeding pool appear in Table 1 with sites on the same creekline prefixed by a common number (e.g. sites 1A, 1B, 1C represent three distinct pools on the same creekline). Vegetation on the banks varied between natural and artificial sites with the vegetation at natural sites being dominated by *Baekea virigata*, *Gahnia sieberana* and *Pteridium esculentum*. At the artificial sites simple vegetation communities existed with one site dominated by *Kunzea ambigua* and the other by *Calochoena dubia*.

DISCUSSION

The breeding sites described here represent the first recorded for this species in southern NSW and the first recorded in over 15 years from the southern populations (i.e. south of Jervis Bay). The habitat features of these sites are broadly similar to those described by authors for the northern populations (Daly, 1996; Rescei, 1996) and for the southern populations from Victoria (Littlejohn & Martin, 1967; Gillespie, 1990).

It seems unlikely that *H. australiacus* is rare as a result of limited breeding sites. Observations of creeklines around the Eden region suggest that a large number of potential breeding habitat sites exist. However, it may be sites which hold a suitable matrix of breeding and non-breeding habitats which are rare and therefore limiting the distribution of the species. The study site lies within the Eden management area. This area contains approximately 500 000 hectares of native forest which have approximately 337 000 mapped drainage features, of which 169 000 are either first or second order streams

(Penman, 2005). It seems unlikely that only a small number of these streams would provide suitable habitat conditions for *H. australiacus*.

It is possible that the species is more widely distributed than currently known but its cryptic nature has limited the number of record localities. Alternatively, the distribution of the species is extremely patchy and there may be habitat features, either in the breeding or non-breeding environment, which are limiting the species distribution that have not yet been identified. Reality may be a combination of these two scenarios, in that the species may have been once widely distributed but historical disturbances (natural and/or anthropogenic) may have resulted in the observed patchy distribution.

A more comprehensive analysis of the breeding habitat across the species range may reveal patterns that have not been identified to date. This analysis would also identify whether differences in the breeding habitat requirements between the northern and southern populations exist. The use of tadpole surveys to locate additional breeding sites in the southern populations would be necessary to conduct such an analysis.

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Table 1. Description of the breeding sites. Ponds prefixed with 1-4 are from natural watercourses and ponds prefixed with 5 or 6 are from sites created from road construction. Site ID identifies the stream (number) and the pool (letter).

Site ID	Site usage	Dimensions (m)	Depth (cm)	Stream order	Cover	Waterbody base	Waterbody edge
1.A	Oviposition	3 x 2	30	2	70%	Rock with heavy leaf litter	80% vege 20% rock
1.B	Tadpole	3 x 3	50	2	80%	Rock with heavy leaf litter	30% leaf 70% rock
1.C	Tadpole	8 x 3	50	2	90%	Rock base with light leaf litter	80% vege 10% leaf 10% bare
2.A	Calling	2 x 1	10	1	80%	Rock base with light leaf litter	20% vege 80% leaf
2.B	Calling	3 x 1	10	1	25%	Rock with heavy wood debris	50% wood 50% bare
2.C	Tadpole	12 x 4	60	1	70%	Rock base with light leaf litter	10% vege 70% leaf 20% bare
3.A	Calling	2 x 1.5	30	1	90%	Rock base with light leaf litter	50% vege 50% leaf
3.B	Tadpole	6 x 1	30	1	80%	Rock base with heavy leaf litter	10% vege 90% leaf
3.C	Calling	3 x 2	30	1	60%	Rock base with heavy leaf litter	40% vege 20% leaf 20% rock
3.D	Tadpole	3 x 3	60	1	30%	Rock base with heavy leaf litter	20% vege 80% leaf
4.A	Oviposition	4 x 1	30	2	90%	Rock base with light leaf litter	80% vege 20% leaf
5.A	Calling and tadpole	3 x 1	30	1	100%	Clay base	80% vege 20% bare
6.A	Calling and tadpole	2 x 1	20	1	100%	Sand base	90% vege 10% bare

EFFECTS OF FIRE ON LIZARD COMMUNITIES IN THE MALLEE SHRUBLANDS OF WESTERN NEW SOUTH WALES

Steven Sass[1,2] and Andrea Wilson[2]
[1]nghenvironmental, PO Box 470, Bega, NSW 2550.
[2]Ecology and Biodiversity Group, Charles Sturt University, Wagga Wagga, NSW 2678.

INTRODUCTION

Fire and its impact on the flora and fauna of Australia remains one of the most important ecological issues for natural resource managers today. Natural resource managers are faced with controlling fire events and prescribed burning which cause major changes in habitat heterogeneity, whilst maintaining biodiversity values across large management areas. However, It is generally recognised that the evolutionary adaptation of Australian fauna to natural fire regimes is a fundamental process within the Australian landscape and by controlling or limiting fire events, changes to community composition and even extinctions of species are likely to occur (Bradstock, 1989)

Within mallee shrublands, fires are devastating events. The high oil content of the mallee eucalypt leaves combined with the highly flammable resin content of spinifex grass (*Triodia scariosa*) and abundant leaf litter promote an environment for extremely hot fires (Bradstock, 1989; Cohn & Bradstock, 2000). One of the most obvious consequences of a mallee fire is the alteration of the vegetation structure. Few areas avoid the devastation of a fire, with all ground and aerial vegetation being destroyed forming a homogenous landscape. As time since fire increases, areas of bare ground are slowly replaced by ground vegetation such as Spinifex grass, regrowth occurs in mallee eucalyptus and shrub layers, and an increase in leaf litter and fallen timber is evident. It is these changes in structural heterogeneity that are likely to impact on the distribution of reptile species across a fire affected landscape.

Despite the fact that mallee shrublands cover over 700,000 hectares across Australia, little is known of the community ecology of lizards living within mallee regions. Previous studies into the effects of fire on lizard fauna in mallee shrublands have been few (Caughley, 1985; Cogger, 1969; Schlesinger *et al.*, 1997). Caughley (1985) found distinct trends in the types of reptiles found in areas of different fire history, with habitat generalists becoming quite common in recently burnt areas while species that had specific habitat requirements such as spinifex dependence were only found in mallee that had not been burnt for at least six years. However, Schlesinger *et al.* (1997) found no difference in species richness or abundance between sites of differing time since fire.

This research adds to the limited information on the response of lizards to fire in mallee shrublands. We discuss the short term effects of large scale fires on lizard community composition within areas of continuous mallee in western New South Wales.

METHODS

Surveys were undertaken in the mallee shrublands of Yathong and Nombinnie Nature Reserves located on the Cobar Peneplain, 150 km south of Cobar in western New South Wales, Australia (Figure 1). These nature reserves host the largest area of continuous mallee shrubland remaining in New South Wales of some 120,000 hectares (NPWS, 1995). The mallee overstorey consists primarily of *Eucalyptus socialis* and *Eucalyptus dumosa*, whilst the shrub layer consists of *Acacia wilhelmiana, Acacia rigens, Melaleuca uncinata* and *Bossiaea walkeri*. The dominant ground cover is spinifex grass (*Triodia scariosa*) and leaf litter.

Lizard sampling occurred in two adjacent mallee stands, one of which was burned in December 2002 by lightning strikes that destroyed almost ten thousand hectares of mallee (termed the burned site) (Figure 2). The adjacent area had not experienced fire for approximately twenty years (termed the unburnt site) (Figure 3). Five sites were chosen at random within the burned and unburned mallee stands using ArcView® Geographic Information System. An existing fire trail was used as the centre of a 600 metre buffer zone separating the burned and unburned sampling locations. This buffer distance was chosen to avoid any spatial influence of the adjacent sampling area and between each sampling location due to the known movement limitations of most reptile species (James, 1991; Turner *et al.*, 1969).

At each of the 10 sampling sites, dry pitfall trap lines were established which consisted of six 20 litre plastic buckets and a 15 metre long, 175 mm high PVC drift fence giving a total of 60 pitfall buckets. Fences were buried approximately 20mm underground to ensure lizards could not pass underneath. Traps were checked both morning and afternoon and were sealed using plastic lids when not in use. In total, traps were open for 12 days between September 2004 and February 2005 over a variety of environmental conditions. All lizards were identified to species level (after Swan et al., 2004) and marked with a non-permanent, non-toxic paint mark to identify any recaptures. In addition, incidental sightings of lizards were recorded whilst walking between the fire trail and sampling site whilst checking the pitfall traps.

Non-metric multidimensional scaling (MDS) analyses were undertaken using the software package PRIMER (PRIMER-E Ltd, 2001). MDS plots were generated to compare the observed faunal assemblages across burned and unburned sites. The statistical significance of any differences observed between reptile assemblages was investigated using analysis of similarities (ANOSIM) (PRIMER-E Ltd, 2001). The ANOSIM tests were conducted using Bray-Curtis calculated similarity matrices. The relative contributions of each species to the differences identified between groups through ANOSIM were further examined using SIMPER analysis in PRIMER (PRIMER-E Ltd, 2001).

RESULTS

A total of 12 species of lizard were recorded during this survey (Table 1). Five species were captured in pitfall buckets whilst an additional seven species were recorded in transects from the fire trail to the location of the pitfall traps (Table 1). The MDS plot of lizard community composition shows substantial separation between burned and unburned sites (Figure 4). ANOSIM demonstrated that these differences were statistically significant ($R = 0.75$; $P = 0.008$). SIMPER shows that *Ctenotus schomburgkii* contributed to 43% of differences. All of the species captured were exclusive to either burned or unburned.

DISCUSSION

An understanding of the impacts of fire in mallee shrublands is critical for natural resource managers if they are to effectively manage biodiversity. Studies of how fire impacts on lizard diversity in mallee shrublands have been few.

Our sampling of lizards in western New South Wales show that although richness and abundance were similar, lizard assemblage was different in composition with no commonality between burnt and unburnt sites. *Ctenotus schomburgkii* was identified as contributing the main differences to these results. *Ctenotus schomburgkii* is a small fossorial skink that can be found across a variety of habitats in arid Australia from sandplains to rocky ridges (Wilson & Swan, 2003). During this study, this species was only found in areas of unburnt mallee shrubland. The results of our study suggest that *C. schomburgkii* may prefer areas of higher microhabitat availability such as spinifex grass and leaf litter over more sparse environments with large open areas such as those presented by a recent fire.

Lizards captured in the burnt mallee were dominated by species such as *Rhynchoedura ornata* and *Egernia inornata* whilst captures in the unburnt mallee were dominated by *Ctenotus atlas* and *Ctenotus schomburgkii*. With no commonality of lizards recorded between burnt and unburnt mallee available microhabitat could be suggested as the limiting factor. It could be generally said that lizards that live in burrows, soil cracks or the burrows of other animals were recorded only in the burnt mallee, whereas the unburnt mallee only produced lizards that require varying forms of refuge for retreat apart from burrows. This would imply that either only those species that can escape an intense fire event rely on retreating to the insulating properties of soil in either their own burrow or that of another species, or that these species prefer open areas for foraging and basking. A recent flush of fresh herbage in the burnt site after rain is likely to explain the presence of *Tiliqua rugosa*.

Law and Dickman (1998) propose that by providing a mosaic of different habitat components across a landscape vertebrate diversity can be maintained or even enhanced. More specifically, fire-driven mosaics over large scale landscapes has been found to be major factor in explaining patterns of lizard diversity in central Australia (Haydon *et al.*, 2000). We also suggest that a more heterogeneous landscape approach by maintaining a mosaic of differing fire history areas will maximise lizard communitiy diversity in these reserves and other large areas of continuous mallee shrubland.

The results from this study suggest that the current regime of the total exclusion of fire from large areas of continuous mallee shrubland to maximise biodiversity value is not an appropriate tool for natural resource managers. The authors suggest that further research is needed to gain a greater understanding of the complex interactions between lizard communities and fire history in large areas of continuous mallee shrubland. In addition, further accounts of individual species ecology of lizards in western NSW should be a priority if researchers are to understand the multifaceted interactions that drive community ecology in this landscape.

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Figure 1. Location of Yathong and Nombinnie Nature Reserves in western New South Wales.

Figure 2. Burnt (less than 3 years since fire) mallee in western New South Wales.

Figure 3. Unburnt (20 years since fire) mallee in western New South Wales.

Figure 4. MDS plot of lizard assemblages sampled from burned and unburned sites (Stress = 0).

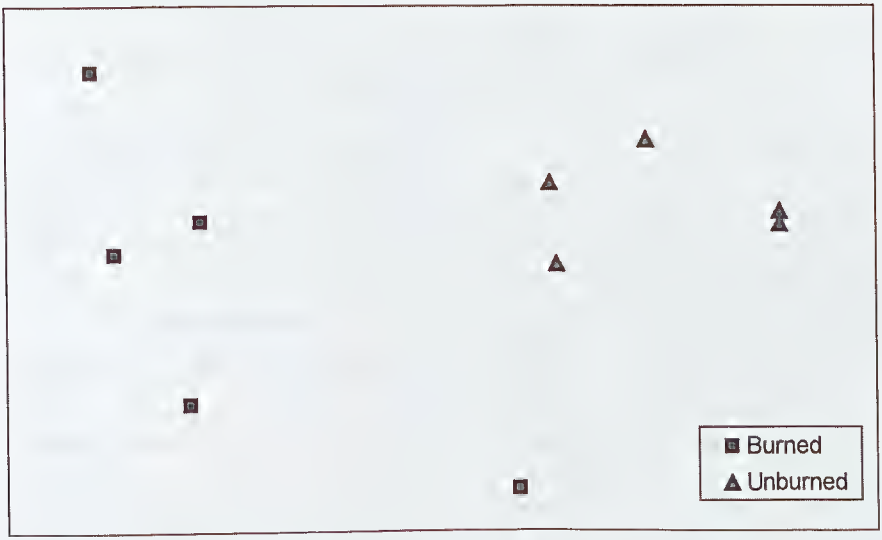

Table 1. Lizards recorded at Nombinnie and Yathong Nature Reserve within each fire history during this study.

R = Recorded (Captured or Observed). P = Pitfall Trap, I = Incidental.

Scientific Name	Common Name	Burnt (2 yrs tsf)	Unburnt (20yrs tsf)
Ctenophorus fordi	Mallee Dragon	R,I	
Ctenophorus pictus	Painted Dragon		R,I
Ctenotus atlas			R,P,I
Ctenotus robustus		R,I	
Ctenotus schomburgkii			R,P,I
Diplodactylus dameus	Beaded Gecko	R,P	
Egernia inornata	Desert Skink	R,P,I	
Pogona vitticeps	Central Bearded Dragon		R,I
Rhynchoedura ornata	Beaked Gecko	R,P	
Tiliqua rugosa	Shingleback	R,I	
Varanus gouldii	Sand Monitor	R,I	
Varanus varius	Lace Monitor		R,I

NEW DISTRIBUTION RECORDS FOR SOME TASMANIAN SNOW SKINKS (*NIVEOSCINCUS*)

Paul Oliver
South Australian Museum, Dept of Herpetology, North Terrace, Adelaide, SA 5000.
Email: paul.oliver@student.adelaide.edu.au.

INTRODUCTION

The snow skinks in the genus *Niveoscincus* are a small monophyletic radiation largely endemic to Tasmania (Melville & Swain, 2000a). They have been studied extensively and have the potential to become a model system for examining a number of ecological and evolutionary questions, notably the evolution of reproductive strategies, ecological niche partitioning and character displacement (Melville & Swain, 2000b; Melville, 2002; Wapstra *et al.*, 1999; for fuller list of references see Hutchinson *et al.*, 2001). Despite this interest basic distributional data is still accruing. While visiting Tasmania in December 2003 I observed a number of species of snow skinks at localities for which to the best of my knowledge they had not previously been reported. Following is a description of these observations and discussion of their significance.

Locality 1. Mount Arthur

Date: 16.12.2003

Time: between approx 9.30 – 11.30 am.

Conditions: very hot (temperature not recorded) and windy, poor conditions for lizard activity.

Locality: Mount Arthur (41°17'S 147°17.5'E) is the smallest of a series of three mountains (1187 m) just to the east of Launceston in north-eastern Tasmania. The other two mountains are Mt Barrow and Ben Lomond. We ascended Mount Arthur via the summit trail starting at Mountain View Road. This path continues up the mountain till it meets a fire access road, then turns and continues up past a fire tower, then along the northern and eastern edges on the mountain top to a summit cairn. Unfortunately, precise altitude data is not available for the observations reported here; however skinks were observed from the first major rock scree on this path all the way to the summit.

OBSERVATIONS

Northern Snow Skink - *Niveoscincus greeni*

Four specimens of this species were observed. They were easily identified by their glossy black ground colour overlain with numerous tiny yellow dots. Skinks were only observed with certainty in the summit region and around the summit cairn. However, it is possible that some other skinks seen only briefly as they disappeared into crevices elsewhere on the plateau were also this species. Definite *Niveoscincus greeni* specimens were only observed on substantial rock outcrops, and not on the intervening scrub habitat. When disturbed individuals tended to escape into one crevice then reappear some distance away out of another. *N. greeni* were observed to both readily jump between rocks and make extensive use of vertical as well as horizontal rock surfaces. All individuals observed were small, considerably under the published maximal length for *N. greeni* of 75 mm SVL (Hutchinson *et al.*, 2000).

Ocellated Skink - *Niveoscincus ocellatus*

Numerous individuals of this large species were observed in all the rocky areas passed through, from below the fire trail and under the treeline up to the summit cairn. While the base colour of observed individuals ranged from light brown and cream to quite dark grey, all had the distinctive ocellated pattern typical of this species. In addition, a number

of large skinks were observed, that were beyond the maximum length (75 mm SVL) recorded for any other species of *Niveoscincus* found on mainland Tasmania, further supporting the identification of these animals as *N. ocellatus*. *Niveoscincus ocellatus* were only observed in areas where rocks were present; however, the vegetation of occupied sites varied extensively, from low heath on the summit through to mixed *Nothofagus* and *Eucalyptus* sp. forest at lower altitudes. *Niveoscincus ocellatus* also tended to be observed on horizontal rock surfaces, and most specimens had single retreat sites that they would routinely disappear into and later re-appear out of. Perhaps not surprisingly given the windy conditions, skinks were most commonly observed in protected areas, such as behind particularly large rock outcrops.

General comments. A fire observation officer was stationed on the top of Mt Arthur when we visited. He reported that on still days skinks (species uncertain) are highly apparent all over the rocks at the top of the Mountain; thus it is likely that actual abundance of skinks is much higher than we observed. This also concurred with my impression that skinks were much less abundant than during a visit two years previously, on a day that was also hot but far less windy. The fire observer also commented that skinks preyed extensively on "hoverflies" that landed on the rocks.

DISCUSSION

Niveoscincus greeni is known from from high (>1000 m) mountains to both the south-east and south-west of Mt Arthur. Nonetheless, there do not appear to be any records of the species from Mt Arthur itself (Hutchinson *et al.*, 2001). With this record *N. greeni* is now recorded from at least three mountains over 1000 metres high to the east of Launceston. *N. ocellatus* is also known from a number of other nearby high altitude sites, including Mt Barrow and Ben Lomond; however, this species again does not appear to have been previously recorded from Mt Arthur. These new localities suggest that other high eastern mountains such as Ben Nevis and Mt Saddleback may also warrant investigation, particularly for further populations of *N. greeni*.

While further surveying is clearly required, on the basis of available data it would appear that *N. greeni* on Mt Arthur occupy a total area of at most a few square kilometers. Two related factors may be responsible for this restricted range. Firstly as was discussed in the original description (Rawlinson, 1975) *N. greeni* is an alpine specialist restricted to areas above the treeline and there may only be a small area of the required high altitude, cool and rocky habitat on this relatively small mountain. Secondly, all available habitat (including the summit) on Mt Arthur is also occupied by *N. ocellatus*. *Niveoscincus greeni* and *N. ocellatus* are both saxicoline forms; however, in most areas they appear to exist largely allopatrically: *N. greeni* on cold mountain peaks and *N. ocellatus* at lower warmer sites (Melville & Swain, 1999, 2000b). Given the otherwise similar ecology of the two species, where they co-exist inter-specific competition is likely to be strong. Furthermore, due to its consistently larger size it would be speculated that *N. ocellatus* would have the advantage in direct competitive interactions; in other *Niveoscincus* it has been documented that larger species tend to exclude smaller taxa from prime habitat (Melville, 2002).

Niveoscincus greeni and *N. ocellatus* are known to occur in syntopy or parapatrically on a number of other mountains around Mt Arthur (Rawlinson, 1975; Melville, pers. comm.). The existence of multiple localities in north-east Tasmania where these two species show differing levels of sympatric interactions provides an opportunity for further research into the processes and outcomes of inter-specific competition between two ecologically and morphologically similar taxa. In particular, the different climatic tolerances of these two species suggest they may provide a system for examining how past (and potential future) climatic changes may affect competitive interactions.

Locality 2. Mount Field National Park

Date: 21.12.2003

Time: 9.30am - 5.00pm

Weather: largely cloudy with occasional patches of sun, felt cold all day (temperature not recorded but estimated under 20°C). Regular bursts of strong wind. Small patches of snow on the Mawson Plateau.

Locality: Mt Field National Park is a popular skiing and recreation area 75 km west of Hobart. The observations reported here were made while walking repeated circuits of Lake Dobson (ca 1030 m) and along the path from Lake Dobson to Lake Seal Lookout (ca 1240 m) (42°41'S 146°35'E).

OBSERVATIONS

Three species of *Niveoscincus* which have been previously recorded from Mt Field National Park were observed (Parks and Wildlife Service, 2003). Metallic skinks *Niveoscincus metallicus* were relatively common in all forested environments up to lower edges of the open alpine heath. Southern snow skinks *Niveoscincus microlepidotus* were abundant in the scree fields on the Mawson Plateau and also occasionally observed in forested environments right down to the junction of Uruquart's track with the Ski Field access road (1080 m altitude). Finally, a single Ocellated Skink, *Niveoscincus ocellatus*, was briefly observed in the boulder field just below the Mount Mawson Ski club hut (1160 m).

In addition, three animals were observed that are likely to represent *N. orocryptus*, a taxon not previously recorded from Mt Field. All individuals were observed on the western edge of Lake Dobson while walking along the Lake Dobson Circuit (Figure 1). They were identified as *N. orocryptus* by possession of dark well-defined vertebral line and wide black lateral line (Figure 2). Unlike *Niveoscincus pretiosus* they lacked light dorsal flecks and were not obviously dorsoventrally flattened. Sympatric specimens of both *N. metallicus* and *N. microlepidotus* were also distinctly different; *N. metallicus* were smaller, much darker and lacked white lateral stripes, while specimens of *N. microlepidotus* had a bronzy sheen, poorly developed vertebral stripes and also lacked a white lateral stripe.

Figure 1. Eucalypt woodland habitat around the southern edge of Lake Seal, Mt Field National Park, locality for *N. orocryptus*.

Figure 2. *N. orocryptus* seen within habitat pictured in figure 1.

All putative *N. orocryptus* were observed in a very restricted area along the western edge of Lake Seal, in *Eucalyptus* woodland with a dense scrub layer. Recognizable components of the scrub layer included Tasmanian waratahs *Telopea, Arthrotaxis* and several species of *Richea*. The three specimens observed were respectively, basking on a rock close to the lake, basking close to the ground on crack in a tree trunk, and basking approximately one metre above the ground on a large fallen branch. The individual on a rock was disturbed on multiple occasions but always returned to the same basking site.

DISCUSSION

It has been suspected that *Niveoscincus orocryptus* existed in Mt Field National Park (Parks and Wildlife Service, 2003); however these are the first tentative records. While the species is regarded as secure (Parks and Wildlife Service, 2003), when problematic hybrid populations from the far south are excluded, Mt Field represents only the fifth confirmed locality for the taxon. While further searching under better conditions is required, even at Mt Field this species appears to be very restricted. Despite extensive searching and abundant sightings of two other *Niveoscincus* species on the same day and in other habitats, *N. orocryptus* was only observed in eucalyptus woodland with a scrubby understory.

Mt Eliza, 30 km to the SW of Mt Field, is the type locality for *N. orocryptus* and the site of the closest confirmed record of *N. orocryptus*. Animals from this site are also reported to show semi-arboreal behaviour and photographed specimens appear to share most features of their pattern with the Mt Field

specimens (Hutchinson, pers. comm.). In addition the habitat partitioning of *N. microlepidotus* in rocky areas and *N. orocryptus* in woodland and scrubby areas was also recorded from Mt Eliza.

Given that Mt Field is one of Tasmania's most visited National Parks and this is only the first record of the taxon, it is clear that more intensive survey work for this species is required to develop an accurate understanding of its distribution and ecology. In particular, on the basis of data presented here and elsewhere, searches should focus on slightly lower altitude scrubby and forested environments which have not been as extensively surveyed as rocky plateau areas.

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DIURNAL SKINKS (*LAMPROPHOLIS DELICATA*) SEEK SHELTER IN THE PRESENCE OF SCENT FROM A NOCTURNAL PREDATOR AND PREY

Alice N. Leung, Thao T. L. Phu, Danielle Lister, Jane Poolice, Leanna Caon, Rebecca Jones, Natasha Chowdhary and Daniel A. Warner
School of Biological Sciences, University of Sydney, NSW 2006.
Corresponding author: Daniel A. Warner, Email: dwar7923@mail.usyd.edu.au.

ABSTRACT

The ability of animals to detect and avoid shelter sites used by predators, and utilise shelter sites occupied by prey, has important implications for survival. We used laboratory experiments to test whether the shelter use of a diurnal Australian skink (*Lampropholis delicata*) is influenced by the scent of a nocturnal predator (snake) and a nocturnal prey item (crickets). We presented skinks with a predator-scented shelter, a prey-scented shelter and a non-scented shelter simultaneously in scented trials. In control trials, skinks were offered three non-scented shelters simultaneously. Overall, we found that *L. delicata* used shelters containing predator scent just as frequently as shelters with prey scent and no scent. However, nearly all skinks (96%) took refuge under shelters when both the predator and prey scents were present in scented trials, whereas only 50% of the skinks took shelter in control trials. Our results suggest that scent cues affect whether or not skinks hide, and that they hide anywhere regardless of the location of the scent, or whether the scent is from a predator or prey.

INTRODUCTION

Shelter choice in animals is important for survival, and the use of shelters by multiple animals may influence the choice of an individual to use that shelter (Downes & Shine, 1998; Langkilde & Shine, 2004). For example, the ability of individuals to detect shelters used by predators and prey can influence their choice of shelter. Moreover, an individual's fitness may be enhanced if it could detect retreat sites that are frequently used by predators or prey, and subsequently select between these retreat sites to avoid sites used by predators and utilise sites used by prey. Indeed, the ability of lizards to preferentially select shelters when faced with multiple situations has been demonstrated. For example, the common garden skink (*Lampropholis guichenoti*) and the velvet gecko (*Oedura lesueurii*) choose shelters that protect them from predation over shelters that enhance resource acquisition when both of these shelters occur simultaneously (Downes & Shine, 1998; Downes, 2002).

However, there has been little research attention focusing on the ability of lizards to prioritise between shelters which allow them to avoid nocturnal predators and shelters which increase foraging opportunities. Diurnal lizards are exposed to nocturnal predators that actively hunt them when they are inactive (Shine, 1984). Thus, an individual's fitness may be enhanced if it could avoid overnight retreat sites that are also used by nocturnal predators. Furthermore, the ability of an individual to utilise retreat sites of nocturnal prey can influence its foraging efficiency. The objective of this study is to determine if the delicate skink (*Lampropholis delicata*) prioritises its choice of shelter when simultaneously presented with a non-scented shelter and shelters that are treated with chemical scents of a nocturnal predator and a nocturnal prey. *Lampropholis delicata* provides an excellent model for addressing these issues because it is an active-foraging diurnal predator of invertebrates including nocturnal prey (crickets), and is also a prey item for actively-foraging nocturnal predators (snakes) (Greer, 1989). Moreover, *Lampropholis delicata* has been shown to display strong responses to scents of various lizard-eating elapid snakes (Downes & Shine, 2001).

MATERIALS AND METHODS

Collection and maintenance of animals

Adult *L. delicata* (n = 35) were collected around Sydney in early and mid March 2005. The skinks were then housed individually in small containers (6 cm deep x 18 cm long x 12 cm wide) at the University of Sydney. One end of each container was placed on top of heating tape to provide the skinks with a thermal gradient in which they could thermoregulate. We placed leaf litter in each container for the skinks to use as shelter. All skinks were fed mealworms (twice per week) and water was always available while in captivity. Skinks were kept in captivity for about two weeks before the scented and control trials began, and were eventually released at their location of capture when the experiment was finished. All skinks used in this experiment were of similar size to one another (snout-vent length mean ± SD = 34 ± 6.7 mm). Both female and male skinks were used in our experiment (and data were pooled for analyses), and since the reproductive season ended prior to our experiment (Joss & Minard, 1985), no gravid females were used.

Experimental design

The scents of a predator and prey item were obtained by placing paper towels in a cage with a single small-eyed snake (*Rhinocephalus nigrescens*) (predator) or with a box of approximately 30 crickets (*Acheta domestica*) (prey); the paper towels (which were later used as a scent stimulus) were left in the snake cage and cricket box for one week prior to the start of the experiment. Although faecal deposits were not present on the paper towels, we observed the scent donors (snake and crickets) sitting or moving over of the paper towels. We chose *R. nigrescens* as the donor of the predator scent because it is nocturnal, occurs sympatrically with *L. delicata* in the Sydney area (Downes & Shine, 2001), and skinks form a large proportion of its diet (Shine, 1984). Indeed, the scent used in our study came from a snake that was regularly fed skinks while in captivity. Moreover, previous studies have shown that lizards avoid retreat sites that hold the scents of sympatric predators (Stapley, 2003) and respond to scents of small elapid snakes such as *R. nigrescens* (Downes & Shine, 2001). Scent from *A. domestica* was chosen as the prey scent because these crickets and similarly-sized insects are readily taken by *Lampropholis* skinks as prey items (Crome, 1981).

To determine if *L. delicata* preferentially selects shelters when the scents of *R. nigrescens* and *A. domestica* are present, we conducted shelter-choice trials in a laboratory experiment. Each trial was performed in a circular arena (45 cm diameter, 30 cm tall), and each arena contained three shelters made from plastic PVC pipes (6 x 12 cm, 3 cm high) cut in half down its length. Under each shelter, we placed 4 x 4 cm pieces of scented paper towel so that each arena contained (1) a shelter with predator scent, (2) a shelter with prey scent, and (3) a shelter with no scent. The shelters were spaced evenly (entrances of each shelter were 5 cm from each other) around the arena, but randomly arranged so that each shelter type was not always in the same location for each trial.

At the beginning of each trial, skinks were placed individually in the centre of the arena and equidistant from each shelter. After 20 minutes, the location of the individual was recorded as (a) inside a particular shelter or (b) outside (not in any shelter). Twenty minutes was chosen as an appropriate time period because it provided skinks sufficient time to settle and select a shelter. Moreover, similar experiments demonstrate no difference in shelter choice between 15 versus 60 minutes after trials began (Langkilde & Shine, 2005). All skinks that were recorded as 'inside a shelter' were found either inside or at the entrance of a shelter. The scented trials were replicated 25 times, and each skink was used only once. We also performed ten control trials under similar conditions and under the same protocol, but without the scented towels. Comparisons within the scented trials, within the control trials, and between the

scented and control trials allowed us to determine if skinks prioritise their shelter choices when predator and prey scents are present.

All trials were conducted over two days (on 31 March and 7 April 2005), and were performed at the same time of day (starting at 1300 hr) in a room at 22°C. Scented trials and control trials were performed simultaneously on both days. In between replicate trials, we wiped down all surfaces with 70% alcohol, and we wore latex gloves to prevent contamination of the shelters and arena by pre-existing scents and handling. Statistical analyses were preformed with chi-square tests. For analyses within the scented trial experiment, our null hypothesis was that an equal number of skinks (approximately 33% in each shelter) will choose each of the three shelters. Our comparisons between experiments evaluated whether or not skinks selected any shelter in response to the scents present.

RESULTS

The within-experiment tests showed that most skinks (24 individuals out of 25) in the scented trials took shelter, but the choice of shelter type did not differ from random (χ^2 = 0.8, df = 2,44, P = 0.661). Skinks took refuge under the predator-scented shelter (25%) just as frequently as under the prey-scented shelter (29%) and control shelter (46%). In the control trials, only 50% of skinks took refuge after 20 minutes. The skinks that took refuge (n = 5) randomly chose shelters (χ^2 = 7.8, df = 3, P > 0.05).

Comparisons between scented trials and control trials showed that the presence of predator and prey scents elicited a response; nearly all (96%) individuals took refuge under one of the shelters in trials where scents were present, but only 50% of the animals in the non-scented control trials took refuge (χ^2 = 9.8, df = 1,33, P = 0.002; Figure 1).

From anecdotal observations, skinks in the scented trials took shelter almost immediately after release into the arena and then remained in the same shelter for the duration of the trial. Individuals in the non-scented trials spent time exploring the arena and never remained under any particular shelter.

DISCUSSION

Overall, our results suggest that scent cues of predators and prey affect whether or not skinks hide, and that they hide under any shelter regardless of the location of the scent. These results imply that *L. delicata* does not preferentially select shelters that hold different types of scent. This was unexpected because numerous studies show that skinks, including *L. delicata*, avoid areas with predator odours (Van Damme *et al.*, 1990; Downes & Shine, 1998; Amo *et al.*, 2004). We propose four explanations for this apparent inability to adjust shelter choice in response to the scents of *R. nigrescens* and *A. domestica*.

1. Lack of evolved response.–*Lampropholis delicata* may not have evolved the ability to detect the scent of *R. nigrescens* and thus, cannot adjust its shelter choice when the scent of *R. nigrescens* is present. Although *L. delicata* occurs sympatrically with *R. nigrescens* in the Sydney area, and the ability of *L. delicata* to detect scents of sympatric predators has been shown (Downes & Shine, 2001), the snake scent used in our study came from an individual collected from a different locality (Morton National Park, 160 km south of Sydney) from our experimental skinks. Thus, the snake scent that we used may have been unfamiliar to the skinks in our study. However, *L. delicata* may be able to detect the scent of skink-fed snakes regardless of collection locality, as studies of other species demonstrate that prey can discriminate between scents based on predator diet (Murray & Jenkins, 1999; Stapley, 2003). Indeed, skinks in our scented trials quickly responded by hiding under shelters in comparison to skinks in the control trials.

2. Predator foraging.–The foraging strategy of *R. nigrescens* may offer another explanation for the apparent inability of *L. delicata* to prioritise between prey-scented shelters

and predator-scented shelters. *Rhinoplocephalus nigrescens* actively forages so it disseminates its scent over large areas (Cogger, 2000). Hence, selecting a retreat-site that does not contain the scent of *R. nigrescens* may be an ineffective predator-avoidance strategy because it provides little information on the location of the predator.

3. Lack of visual cues.–Although scincid lizards have a well developed olfactory system, visual cues or direct interactions may provide the information upon which final decisions are made (Langkilde & Shine, 2005). The inability of *L. delicata* to select the shelter with the scent of crickets may indicate that visual cues are more important than chemical cues when hunting crickets since most scincid lizards only consume active prey (Nicoletto, 1985). Although crickets are considered nocturnal and are often inactive when *L. delicata* forages during the day, we have observed crickets frequently moving under shelters and occasionally leaving shelters during daytime hours. Thus, *L. delicata* is likely to encounter active crickets during their daily lives.

4. Scale of set up.–Lack of preference for any specific shelter may be attributed to the scale of the experimental set up. The shelters within the arenas were placed 5 cm apart; this distance may be too small to treat shelters independently. Hence, skinks may have treated all shelters as equally unsafe and hiding under any shelter could have been a reasonable strategy to avoid predation. This was supported by the anecdotal observation that nearly all skinks in the scented treatment took shelter immediately and remained there for the duration of the trial. In addition, a significant effect was evident in comparisons between scented and non-scented trials: only 50% of skinks in the control treatment sought refuge and only after exploring the arena first (Figure 1) while 96% of skinks sought refuge in the scented trials.

Our experiment showed that diurnal skinks respond to scents of nocturnal predators and/or prey, but hide anywhere regardless of the location of the scent. We can envision a greater benefit of seeking shelter in response to predator scent than to prey scent. For example, if a predator scent is present, a lizard may increase its chances of survival by seeking nearby refuge (Downes, 2001). On the other hand, if prey scent is present, seeking shelter is likely to have little to no impact on survival. Due to the strong responses that we observed in this experiment, our impression is that skinks were responding primarily to the predator scent. Overall, our study provides some indication that *L. delicata* adjusts its shelter choice behaviour when the scent of its nocturnal predator is present, but this needs to be confirmed by further experimentation. In general, this study provides further evidence that chemical cues are important factors that influence behaviour, such as seeking shelter.

ACKNOWLEDGMENTS

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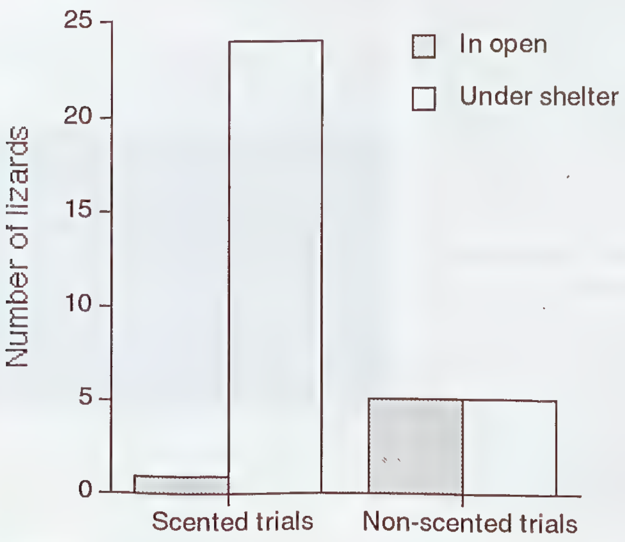
Figure 1. The effect of the presence of scent (from predator and prey) on shelter choice by *Lampropholis delicata* (χ^2 = 9.8, df = 1,33, P = 0.002).



A CASE OF "DEATH BY FUR-BALL" IN A YOUNG FRESHWATER CROCODILE (*CROCODYLUS JOHNSTONI*)

Raymond Hoser
488 Park Road, Park Orchards, Victoria 3114.
Email: adder@smuggled.com.

Freshwater crocodiles are rarely kept by private hobbyists in Australia, and as a result relatively little has been published on their captive husbandry and the problems that may arise. I obtained a 27 cm (total length) freshwater crocodile on 29 June 2004 and housed it in a tub of heated water. On about 17 September 2004 the crocodile appeared "off colour", its eyes were not open fully and it had suddenly lost its normally voracious appetite. Non-feeding continued, and on 23 September 2004 the crocodile regurgitated its last meal (from 16 September 2004), and it was found dead the next day.

When the dead crocodile was opened up it revealed a huge, hardened oval shaped mass of fur (as in a fur-ball) in the stomach, measuring over 3 cm long and about 1.8 cm in diameter. This could be readily felt through the body wall of the dead crocodile prior to post mortem. The undigested fur-ball had probably blocked the passage of food through the stomach, causing decomposition, and eventually death.

When first obtained, this crocodile was fed a variety of food items, but as it showed a preference for rodents this came to be its entire diet. I fed it the legs of dead mice, which I removed before the mice were fed to captive snakes.

A second crocodile of similar size acquired on 16 October 2004 was also fed on a diet of rodent legs, but always with the fur removed. As of late 2005, this crocodile remains in perfect health. Dunn (191) cited the case of all four young *C. johnstoni* at Melbourne Zoo dying from fur impaction after being fed on a diet of rodents. This may be a relatively common but undetected cause of death in captive freshwater crocodiles, especially where a post mortem is not carried out on the animal.

ACKNOWLEDGMENTS

Brian Barnett (Victoria), Adam Britton (NT), Scott Eipper (Victoria), Adam Elliott (Victoria), David Heading, Brad McDonald (NSW), Peter and Judy Whybrow (Victoria) all gave valuable advice in terms of housing and husbandry for the crocodiles. Licences for the movement and possession of the said animals were provided with expediency by the South Australian and Victorian wildlife authorities and this was appreciated.

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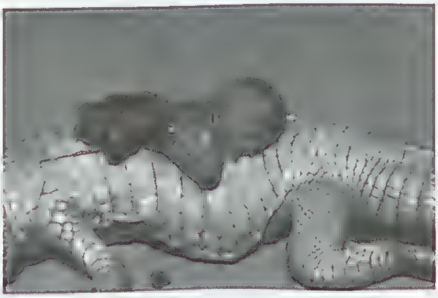
Figure 1. Fur ball removed from juvenile freshwater crocodile



BOOK REVIEW: STEVE'S GUIDE TO SNAKES OF THE NORTH COAST & TABLELANDS NSW

By Steve McEwan, 2005.
36 pp. + inner covers, A5 format, 66 colour photographs.
Published by Steve McEwan's Reptile World, Coffs Harbour, New South Wales.
Available in paperback only, no dustwrapper.
RRP AU$13.95. No ISBN.

Steve McEwan is a herpetologist and public educator well-known to the local communities of the north coast of New South Wales in his occupation as traveling lecturer to children and adults about reptiles and other wildlife. His involvement with reptiles has been life-long, and he commenced his professional herpetological career at the Australian Reptile Park at Gosford working under the guidance of Eric Worrell, as have many other Australian herpetologists of note. For more than ten years, he has been a resident of Coffs Harbour, and has amassed a wide experience and knowledge of the local fauna, which underpins the present work; this is his first book.

There is an introductory letter by the author (inside front cover), Contents page, and then one species account per page for each of the snake species recorded from the two regions under common name headings (Latin names are not given), with venom status (toxicity to humans), maximum size, and brief description of morphology, habitat, activity pattern, diet, and snake-bite symptoms and advice, accompanied by one to four (mostly two) photographs. Following the species accounts are general biological sections: Shedding, with descriptions of the process, and photographs of sloughing in *Dendrelaphis punctulatus* (Colubridae) and *Demansia psammophis* (Elapidae); Mating, with details concerning finding partners, copulation versus male combat, and a photograph of a "mating ball" of *Morelia spilota mcdowelli* (Pythonidae); Reproduction, with discussion of mode and egg/litter deposition sites in snakes, and photographs of *M. s. mcdowelli* female and egg-mass and an egg-mass with emergent heads of six neonates; Treating Snake Bite, with description of first aid procedures, accompanied by photographs of a snakebite first aid kit and of pressure bandage application and limb immobilisation of an arm and a leg; and (on inside back cover), Contact Details for Steve, local wildlife organisations, Acknowledgements, and References Used sections; there is no index. The author's biographic summary, publisher and year of publication are on the back cover. The excellent colour photographs are all by the author, mainly of wild subjects from the two regions covered tkaen on "natural" backgrounds mostly *insitu* at the site of discovery (S. McEwan, pers. comm. October 2005) thereby illustrating each species in its substrate context.

The 29 species accounts (27 snakes, 2 legless lizards) are organised by family. Only one of three blind snakes (Typhlopidae) known from the regions, *Ramphotyphlops nigrescens*, and only one of nine sea-snakes (Hydrophiidae) recorded from NSW waters by Swan *et al.* (2004), *Pelamis platurus*, are included in this book. Two of the four regional legless lizards (Pygopodidae), *Lialis burtonis* and *Pygopus lepidopodus*, are included for comparison, although examples of the several species of reduced-limbed skinks (Scincidae) occurring in the two regions are not.

The book is printed on gloss paper, and quality of print and photographic reproduction is high. I could find no readily apparent typographic or printing errors other than trivial absence of a comma and full-stop after "eg" on p. 35, nor errors of fact in the simple, succinct but informative biological summaries which have a local focus. I am a great believ-

er in the usefulness of Latin names, especially for young beginners in herpetology, and there would have been enough space at the top of each species account for inclusion of the Latin family name and species binomen. Field data (locality, date, time, habitat) could have been provided for photographic subjects as captions. Other than these minor criticisms and the small gaps in coverage of rarely observed fossorial and marine snakes, for the price, this is a little gem, particularly for the specialist age group (7-14 yrs.) at which it is primarily aimed, and for the non-specialist naturalist or bushwalker wishing to have an identification guide to snakes of these two NSW regions. The regional photographic coverage and the many natural history facts from the author's personal experience with the region's snakes expand its utility to older herpetological specialists, and it is also essential for all those wishing to obtain a complete set of titles in Australian herpetology. I therefore recommend this little book for all Australian herpetologists' libraries.

The book is currently available in National Parks shops and some bookshops in northern NSW, but is published by the author and is not widely distributed via usual outlets; it may be ordered for $10 + $5 postage and handling from the author by email [steve@reptileworld.net.au; further information about the author and regional herpetofauna on website, www.reptileworld.net.au].

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Dean C. Metcalfe,
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BOOK REVIEW: THE FROGS OF NEW GUINEA AND THE SOLOMON ISLANDS

By James Menzies, 2006
346 pp., 173 colour photographs of species
Published by Pensoft Publishers, Geo Milev str. 13a, Sofia 1111, Bulgaria.
R.R.P. A$85 - $100 ISBN 10:954-642-273-8

Over the past two decades numerous volumes have been published on the frog faunas of nations or specific geographic areas. In Australia frogs are so popular that there are field guides to area of dense human population such as Sydney and Perth, as well as to entire States and Territories.

New Guinea, the Solomon Islands and off-shore islands have an extremely rich frog fauna which was last treated in its entirety by Van Kampen (1923). A vast number of new species is still being discovered. Blum and Menzies (1988) described no less than nine new species of *Xenobatrachus* and *Xenorhina* in a single paper. For anyone approaching a study of New Guinea frogs a major problem is assembling the literature because it has become so widely scattered. As Menzies comments, "In the last five years alone, papers concerning New Guinea's frogs have appeared in 18 different journals in six different countries...."

James Menzies' new book brings together accounts of all species known at December 2005 and is a phenomenal resource.

Following the Introduction there is a brief account of the diversity and biology of the frog fauna of the New Guinea region, and then a description of the topographic and climatic features that contribute to the diversity.

Nineteen pages are devoted to origin and biology. This is an extremely valuable section and transmigration of taxa between Australia and New Guinea is critically examined against the known events of the evolution of New Guinea since the Eocene. Then there is a discussion of the characters used in identification, and a valuable tabular matrix of the presence of 17 characters in the 32 genera recognised.

The bulk of the book is devoted to the systematic accounts of the 338 species and six families. Each species entry has a section on field recognition followed by information on ecology (if known) and geographic distributions. Waveforms and sonograms of 146 species are grouped as an Appendix, whilst a second Appendix includes numerous distribution maps. A useful Gazetteer, Glossary, Reference list and Index follows.

No less than 173 colour illustrations of the various frog species are included, mostly taken by the author. There are also ten superb habitat shots of montane and lowland forested and deforested areas that will whet the appetite of any herpetologist toying with the idea of a visit.

Being a compilation of what is known there are no nomenclatural changes. The ranid genera *Fejervarya* and *Limnonectes* are both recognised, as are the increasing number of microhylid genera. To what extent the various proposals of Frost *et al.* (2006) will impact upon the New Guinea fauna remains to be seen. It is certainly feasible that *Xenorhina* and *Xenobatrachus* will be synonymised.

This volume is number 48 in the Pensoft Series Faunistica. Only 500 copies have been printed and I hope that they sell out quickly so that a revised volume can be released correcting a few typographical errors. However, this in no way detracts from a significant contribution to the world's herpetological literature. It is of particular value to anyone interested in the frog fauna of northern Australia.

Although this book has been published in Europe, it can be obtained from the sales outlets of Mike Swan and Andrew Isles, or directly from the publisher. I commend it most highly.

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Michael J.Tyler
School of Earth and Environmental Sciences
University of Adelaide, SA 5005

BOOK REVIEW: FROGS A CHORUS OF COLORS

By John L. Behler and Deborah A Behler, 2005.
159 pp. Sterling Publishing Co., New York.
RRP $34.95 ISBN 1– 4027-2814-X

Looking back at over fifty years of herpetology I know that I have picked up dozens of frog books that are simply pictorial. They have nice pictures but usually no substance, with poor text and are usually too expensive to even think of buying. With this biased background I approached this book but found it different from any that I had seen before. "Frogs a Chorus of Colors" is by far the best 'popular' book I have ever encountered, and by far the best buy.

So what is it that makes this book so special? Partly it is the design which is brilliant plus the numerous photographs which, without exception, are superb. Added to this the text is informative and accurate. The only way to assess it is to check back on those issues with which you are familiar and, when I did this I found nothing wrong.

The book is divided into eight chapters of which the one describing families is by far the longest and most informative.. Every one of the thirty recognised is represented, including the recently described Nasikabatrachidae of western India, found as recently as 2003. Obscure groups such as the Allophrynidae are represented and illustrated.

"Frogs a Chorus of Colors" is distributed in Australia by Capricorn Link (Australia) Pty Ltd, PO Box 704, Windsor, NSW 2756. I recommend this book without any reservations.

Michael J.Tyler
School of Earth and Environmental Sciences
University of Adelaide, SA 5005

BOOK REVIEW: REPTILES OF THE SOLOMON ISLANDS

By Mike McCoy, 2006.
212pp., 128 colour photographs.
Published by Pensoft Publishers, Geo Milev str., 13a, Sofia 1111, Bulgaria.
R.R.P. 45 Euro (about A$80-100). ISBN 10:954-642-275

This is the third publication under this title by Mike McCoy, a well-known naturalist and photographer who was resident in the Solomon Islands for 26 years. The first was a slim book of 80 pages, published in the Wau Ecology Institute (Papua New Guinea) Handbook series in 1980. In 2000, he followed this with a privately published CD. The new book, while under the same title, is not merely a new edition of the previous book or the CD, but an entirely new work of much larger size from a different publisher.

A hardback for the first time, this new book is profusely illustrated with 128 superb colour photographs, reproduced at half page size. The original book had just 64 colour photographs, eight to a page (and on smaller pages), supplemented by 37 black and white photographs, two to four to a page. As the known reptile fauna is only about 85 species, several species are illustrated by multiple photographs, covering sexual, ontogenetic, geographic and individual variation. Not all species are illustrated in life (a handful are only known from a few old specimens, although photographs of museum specimens are provided for almost all of these).

The book's coverage includes the entire Solomon Islands nation, and hence extends to the south-east to the Santa Cruz Islands, which has a fauna with elements from Vanuatu. To the west, it also sensibly includes Bougainville Province of Papua New Guinea, which has a fauna closer to the Solomon Islands than to Papua New Guinea. The reptile fauna of the region, while of similar familial diversity to Australia (with Boidae replacing Pythonidae) has very different elements at the generic level, including unique genera and species (such as the Prehensile-tailed Skink, *Corucia zebrata*, and the elapid snake genera *Loveridgelaps, Parapistocalamus* and *Salomonelaps*). While many species and genera are widespread in the western Pacific, recent studies have demonstrated that the Solomon Islands representatives are often distinct. Hence, in comparison to the 1980 book, there have been at least 17 changes to the generic, species or subspecies status of species previously known from the Solomon Islands, together with the description of several new species not previously known by other names (some of which were discovered and/or described by McCoy during this period).

The author has kept abreast of the literature and consulted widely with recent researchers on this fauna, as well as being thoroughly familiar with most of the species in life. Consequently, the book is not just a superficial compilation for the popular market, but a thorough synthesis of all the previous literature, supplemented by a wealth of new information based on personal experience as well as hints of what is to come. As noted by McCoy, several species (e.g., in the scincid genus *Sphenomorphus* and the gecko genus *Cyrtodactylus*) are certainly currently undescribed (and being studied by others). McCoy offers a critical opinion of the literature based on his own experience. Hence, he does not blindly accept every taxonomic statement, but in some cases offers his own opinion. For example, he notes that the purported diagnostic character of tail base shape of the recently described *Varanus juxtindicus* Böhme *et al.*, 2002, from Rennell Island, is not robust based on his examination of live material, and hence does not accept that species as distinct.

While the book is a little large (165 x 240 mm) for a pocket field guide and more suited to the lab or office, it includes checklists of the fauna by island, a very useful feature for the herpetologist or tourist likely to only visit one or two islands of this extensive archipelago at a time.

The only negative feature, given the relative lack of previous comprehensive taxonomic study of the Solomons herpetofauna (most of the taxonomic literature consists of descriptions of single taxa from small samples, without consideration of patterns of geographic variation) is that the island species lists do not indicate the source of the record, and whether voucher specimens exist. From my own work on *Sphenomorphus*, using museum collections worldwide, representative samples (or in many cases even single voucher specimens) don't exist from every island for each species. Hence, visiting herpetologists may be discouraged from collecting samples, believing that they already exist. This in turn hampers detailed revisionary work on the fauna: with such an extensive archipelago, with difficulties in transport and resource availability in many regions, targetted fieldwork to sample for specific species throughout the region is not viable financially or time-wise, and opportunistic collecting resulting in the slow accretion of material over multiple generations of herpetologists is necessary for future work.

This criticism apart, this book is a new benchmark for knowledge of the region's herpetofauna. Given the rate at which the archipelago's forests are being exploited in the current troubled economic climate, and with likely changes in sea levels and climate from global warming within the next century, this book will hopefully stimute a new cycle of taxonomic and ecological research in this remote part of the Pacific, before the fauna disappears.

REFERENCE

Böhme, W., Philipp, K. & Zeigler, T. 2002. Another new member of the *Varanus* (*Euprepiosaurus*) *indicus* group (Sauria, Varanidae): an undescribed species from Rennell Island, Solomon Islands. Salamandra 38: 15-26.

Glenn M. Shea,
Faculty of Veterinary Science,
University of Sydney, NSW 2006.

NOTES TO CONTRIBUTORS

Herpetofauna publishes articles on any aspect of reptiles and amphibians. Articles are invited from interested authors particularly non-professional herpetologists and keepers. Priority is given to articles reporting field work, observations in the field and captive husbandry and breeding.

All material must be original and must not have been published elsewhere.

PUBLICATION POLICY

Authors are responsible for the accuracy of the information presented in any submitted article. Current taxonomic combinations should be used unless the article is itself of a taxonomic nature proposing new combinations or describing new species.

Original illustrations will be returned to the author, if requested, after publication.

SUBMISSION OF MANUSCRIPT

Two copies of the article (including any illustrations) should be submitted. Typewrite or handwrite (neatly) your manuscript in double spacing with a 25mm free margin all round on A4 size paper. Number the pages. Number the illustrations as Figure 1 etc., Table 1 etc., or Map 1 etc., and include a caption with each one. Either underline or italicise scientific names. Use each scientific name in full the first time, (eg *Delma australis*), subsequently it can be shortened (*D. australis*). Include a common name for each species.

The metric system should be used for measurements.

Place the authors name and address under the title.

Latitude and longitude of any localities mentioned should be indicated.

Use the Concise Oxford Dictionary for spelling checks.

Photographs – High resolution digital, black and white prints or colour slides are acceptable.

Use a recent issue of Herpetofauna as a style guide.

Electronic manuscript may be submitted to the editor via email or on a CD. It needs to be in Word format.

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REPRINTS

The senior author will receive a PDF copy of their article.

Mountain Snow Skink, *Niveoscincus orocryptus*, from Mt Field National Park, Tasmania. See paper on distribution of this species on page 112. (Photo: P. Oliver)

Pygmy Bluetongue, *Tiliqua adelaidensis*, with bifurcate tail regeneration. See article on this species on page 68. (Photo: A. Fenner)